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14. Abstract As part of an international humanitarian demining effort, Congress provided the Army $10M of FY95 RDT&E funds with direction to develop and demonstrate technologies applicable to humanitarian demining and other Military Operations Other Than War (OOTW) situations. Congress further directed that the technologies developed under this one-year only program be shared in an international environment. In compliance with this direction, the CECOM Night Vision and Electronic Sensors Directorate (NVESD) developed, demonstrated and validated over 30 prototype items for humanitarian demining in 1995.

15. Subject Terms Executive Summary, Test Plan, Mine Detection On-Road and Off-Route, Mine Clearers, In-situ Neutralization, Individual Components

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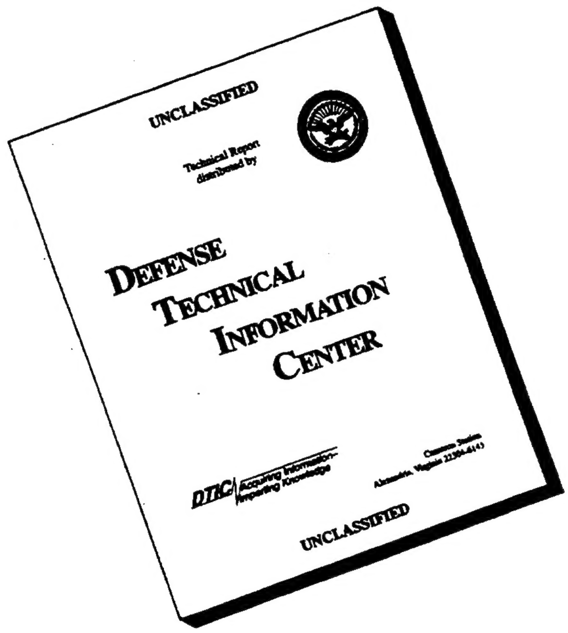

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CONQUEST OF DARKNESS

VOLUME II

Countermine Technologies for Humanitarian Demining

Test Results Report

December 19, 1995

VOLUME II

COUNTERMINE TECHNOLOGIES FOR HUMANITARIAN DEMINING

TEST RESULTS REPORT

December 19, 1995

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Test Results Summary

This test results report provides an evaluation of each item's performance at the OCDT. This report groups each item into one of four categories:

- On-road and off-route detection comprises three vehicle mounted systems to detect mines using a variety of sensors.

- Mine Clearers consists of two remote control vehicles that clear AP mines.

- In-Situ (in-place) neutralization covers five technologies for safely neutralizing mines where they are found.

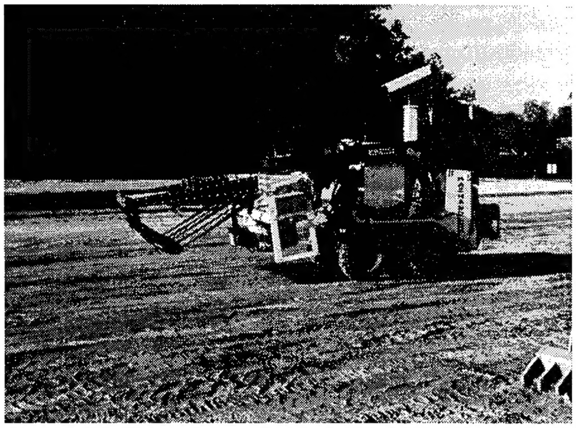
- Individual Components captures a wide range of demining technologies from the simple to the sophisticated. This category contains the largest number of prototypes. There are detectors, markers, large and small area clearing devices and aids, vehicle protection kits, a mine awareness training system, a special tool kit optimized for demining and miniature helmet or pole-mounted cameras with data, voice and audio communication links from the operator to the controller/trainer.

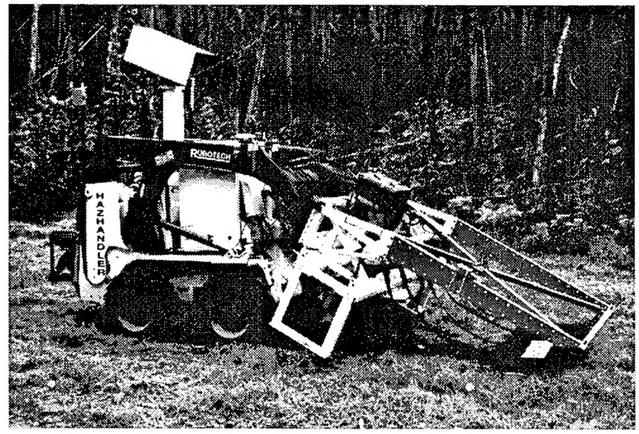
The OCDT was extremely successful. Within two months after receipt of the funds for this program, the NVESD managed the development of 31 different prototypes from contracts awarded under the Broad Agency Announcement process, from existing contracts, from other DoD agencies and from its' own laboratories. Developers had roughly five months to deliver working prototypes for test. Given this challenge, the percentage of items that met or exceeded performance requirements was very high. Some were so successful that they can now be used for humanitarian demining.

Data collected during the test, input from test personnel and contractor reports were inputs to the analysis that led to the following evaluation. The NVESD at Fort Belvoir, VA maintains this documentation. The report on each humanitarian demining alternative consists of an opening paragraph and a performance evaluation. The opening paragraph for each item contains an abbreviated description and provides reference to the full description in the Test Plan. The opening paragraph also refers to the location of the detailed plan for test for that item in Appendix D of the Test Plan. The evaluations are keyed to the measures of success for each alternative as stated in Appendix D. The last part of the report contains conclusions and recommendations by item.

I. On-road and Off-route Detection:

Vehicle Mounted Detection System





1. The Vehicle Mounted Detection System (VMD) is a multi-sensor mine detection system mounted on a remote control vehicle. Refer to paragraph (A)(1) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section I, paragraph A.

2. Performance Evaluation:

The Vehicle Mounted Detection System (VMD) consists of three types of sensors: a metal detector, a Thermal Neutron Analyzer (TNA), and an infra-red (IR) and ultra-violet (UV) video anomaly detection suite of cameras. Each of the systems was tested separately in the concrete, asphalt, grassy field, and pattern mine field test areas and were used in a combined test in the off-road area.

a. How many mines did the entire system find?

(1) The metal detector indicated eight targets, and the visual systems detected three.. The TNA interrogated eight of the targets and correctly indicated four as large anti-tank mines and four as metal clutter targets.

(2) The metal detector was sensitive enough to pick up all metal in the ground of certain mass and depths as detailed in the next paragraph. The TNA sensor was easily able to indicate the presence of all anti-tank mines and some of the large anti-personnel mines. The camera systems require further testing in better weather conditions.

b. Were all the mines found with the metal detector?

(1) The metal detector easily found all mines with detonators, high metal content or that were flush buried. In the grassy field, the operator of the metal detection array was able to detect buried metal fragments whose weight ranged from less than one gram to thousands of grams. Mines and shrapnel fragments of one gram metal content that were buried less than or equal to one centimeter were detected. The VMD easily detected all non-metallic mines tested that had proper metal content detonators. These included the VS-2.2, VS-1.6, VS-50, PMD-6 and a VS-50 all at a two inch depth, and a M14 at one inch. In the concrete area, system operators were able to detect metallic mines buried in potholes of the section containing steel reinforcing bars, as well as the standard concrete section and asphalt.

(2) Due to safety concerns, some of the mines did not have detonators and thus had far lower actual metal content that would be found in active mines. These mines were not expected to be detected by the metal detector system so they did not score as missed mines. The low metallic content mines were buried below the operational level of the mine to test the limits of the metal detector.

c. How many mines were found with the infra-red/ultraviolet (IR/UV) system? Weather conditions during the November test precluded extensive testing of the commercial IR/UV cameras. However, the camera system was able to display a few anomalies that were buried anti-tank mines, as well as other buried objects. Based on test observations, the concept of multi-spectral video mine detection for humanitarian demining does appear possible because deminers have the capability to wait until conditions favor this method.

d. How accurate was the Thermal Neutron Analyzer (TNA) sensor in verifying the presence or absence of a target in the different areas?

(1) The grassy field calibration lane contained six anti-tank and four anti-personnel land mines. Nine of the mines were interrogated with the TNA sensor. The explosive content of the four large 12-20 pound anti-tank mines, M-19, M15, TM-62, and TMD-44, was detected during field operations. Each test took approximately two minutes. The explosive in the eight pound VS-2.2 and four pound VS-1.6 anti-tank mines was also detected in about four minutes.

(2) The VMD was tested against three of the four anti-personnel mines; a VS-50, a PMD-6 and a TS-50. The real-time TNA results were inconclusive for the anti-personnel mines. However the contractor post-processed the data at his facility after the field test to determine if the system was able to detect the nitrogen content of the anti-personnel mines. Post-processed data indicated that the TNA can easily detect all anti-tank mines and some anti-personnel mines that contain a half pound or more of explosive. Also note that the background nitrogen level occasionally varied substantially over distances of a few meters. These variations were comparable to the largest signal seen from the anti-personnel mines thus indicating the machine has a minimum operational level that can be achieved. The post processed data indicated the system has the capability to positively tell if a metal object is an anti-tank mine or a large anti-personnel mine.

e. Can the suite of video equipment detect trip wires and directional mines in the wooded areas? Trip wire and off-route directional mine detection capability requires further testing.

f. How accurately does the marking system mark the objects it detects? The marking system was not tested due to technical problems. It is a key piece of the system for actual field use and should be tested in the future.

g. What is the false alarm rate for the close-in and stand-off sensors?

(1) The false alarm rate for the metal detector was high because of the large number of metal fragments in the test area. At times, the shrapnel outnumbered the mine targets by 10 to 1. This result was expected because the metal detector is designed to detect every trace of metal in the ground. This demonstrates the validity of having other sensors such as TNA and IR/UV to classify a metal detection as mines or clutter.

(2) The video system also had a high false alarm rate because it detects anomalies in the soil. Another sensor such as the TNA or metal detector was then used to classify the targets. The TNA did not have false alarms. Objects interrogated were either anti-tank mines, or possible anti-personnel mines and were treated as such.

h. In which area did the system work the best? The system worked equally well in all areas, but is most suited for anti-tank mine detection on roads. The system could positively indicate if a target was an anti-tank mine or not an anti-tank mine.

i. What times during the day and under what conditions (weather, heat, light, ground covering, etc.) are the sensors most accurate in detecting land mines and trip wire devices?

(1) The system worked the best when the ground was hard and dry. The metal detector was a flexible array and demonstrated the ability to conform to uneven terrain such as wheel ruts where anti-vehicular mines are often buried. The TNA is not affected by uneven terrain, but the camera suite must have a clear field of view to spot surface anomalies.

(2) The metal detector performance was not affected by rain, and the TNA was only marginally affected by moisture in the soil, losing an estimated 5% of its resolution. The IR/UV camera suite becomes ineffective when the ground is saturated with recent rains and works best on dry soil.

j. How easy is the vehicle mounted mine detection system to set up, operate and maintain? How many hours of training are required? The TNA subsystem is complex to set up and requires personnel trained in handling neutron radiation sources. The metal detector subsection is easy to set up and operate, as well as the camera suite and require a few hours of training.

k. How good is the quality of the video that is transmitted back to the command station? What is the quality of the 3-D images that are transmitted to the command station? Can the shape of the buried device be determined? The quality of the video in infra-red and ultra-violet was excellent and more testing under favorable conditions is necessary to assess the capability of video detection systems.

Vehicle Mounted Mine Detection (VMMD)

1. The VMMD is a multi-sensor mine detection system mounted on a small utility vehicle. The primary sensor in the VMMD is a Ground Penetrating Radar (GPR). Refer to paragraph (A)(2) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section I, paragraph B.

2. Performance Evaluation:

a. **Determine percentage of landmines that can be detected after each pass using a combination of the infrared (IR) and ultraviolet (UV) stand-off sensors, and the ground penetrating radar (GPR) close-in sensor?**

(1) The VMMD system demonstrated the capability to detect anti-tank mines and some antipersonnel mines at various depths using the IR/UV stand-off sensors and the ground penetrating radar close-in sensor. Overall detection of antitank mines was approximately 70% for both off-road and on-road conditions. Overall detection of antipersonnel mines was approximately 33% with a high percentage of false detections (detections not identified as mines).

(2) These percentages can be somewhat misleading for the following reasons. First, some of the AP mines were buried 6" to 8" deep to test the overall capabilities and/or limitations of the system, realizing that these were not standard mine depths. Second, rainy weather conditions experienced

throughout testing may have affected the system and its detection capabilities. The GPR does not work as well in heavily saturated areas due to a phenomenon known as "ground return" as the images received are blended together. Finally, these percentages are based on a small sample size.

(3) The IR and UV standoff sensors were used in a limited role due to the extreme weather conditions (rain and cold temperatures). A noise equivalent temperature differential (NEDT) of less than 0.1 degree can achieve it's maximum detection in favorable conditions. However, to handle more stressing weather or terrain conditions, an NEDT approaching zero is required. A FLIR Systems, Inc. (FSI) Prism camera with a 30 degree diagonal Field of View (FOV) and an NEDT of less than 0.1 degrees C was used during the demonstration. However, a state-of-the-art 0.02 degrees C Quantum Well Prism camera from FSI will be integrated onto the system once it is complete. Data collection included an additional side by side direct evaluation and comparison of a laboratory prototype quantum well longwave infrared (LWIR) against a combination of the FSI LWIR and an Inframetrics mediumwave infrared (MWIR) imaging system. In terms of NEDT, the improved sensitivity of the quantum well was superior to the MWIR and scanned LWIR cameras.

b. What percentage of landmines are detected in both on-road and off-road environments? The VMMD system's overall detection rate for the off-road environment was 50%. However, the VMMD detected 92% of the antitank mines in the Sand, Patterned Field and Unimproved Road areas. The system detected 33% of the antipersonnel mines. On the On-road areas (Gravel, Asphalt, and Concrete areas), the VMMD system achieved 60% detection for antitank mines and 53% of the empty holes that were present. Again, these figures may be somewhat misleading due to the reasons mentioned above.

c. What is the reported type and diameter of the mines that are detected and those that are undetected? The 70% detection achieved for antitank mines included the following mines (TMD-44 box mine, TM-62, TM-46, M-19, M15, VS-2.2, and the VS-1.6). Of the 33% antipersonnel mines detected, the PMD-6 box mine and the M16 or Valmara 69 bounding mines were the most often detected. The VMMD system had trouble detecting the VS-50/TS-50 series as well as the M14 antipersonnel blast mines due to their smaller size.

d. What times during the day and under what conditions (weather, heat, light, etc.) are the stand-off sensors most accurate in detecting landmines? The optimal time of day and weather conditions were not recorded due to the limited testing time. Continual rain, cold weather and mechanical problems forced the testers to prioritize the data collection. Since the weather was somewhat constant throughout testing (cold, windy, and rainy), this criteria was eliminated from this test.

e. How easily is the vehicle mounted mine detection system set up, operated and maintained? How many hours of training are required? The VMMD was difficult to set up and maintain as configured at the demonstration. The process involves setting up the ground penetrating radar, the communications links between the GPR and the on-board CPU and between the on-board CPU and the control station, the paint marking system, the GPS system, and the computer and control operations at the command and control station. As the GPR and communications software improves, system set up may be greatly simplified. The VMMD system also required continuous maintenance to keep the system operational. Software problems caused the most down time followed by various hardware problems. Cold weather affected the onboard computers, sometimes causing the system to shut down.

During the demonstration it took a team of experts in computer software, hardware, GPR, IR/UV cameras and GPS to operate the system. The prototype did not have remote control. However, the GIS display was easy to operate given adequate training. There should be one button that turns the entire system, or each subsystem on and off. The system should be immediately ready to communicate to the GIS display and the GPS once it is operating. Once the VMMD is operating,

there should be an optimal set distance above the ground to operate the GPR assembly for each different surface and environment.

f. What are the possible safety hazards if any, that may occur when operating the equipment? There are no major safety factors other than having an on board VMMD operator. However, since this system would be remote controlled in later configurations, this safety concern would be eliminated.

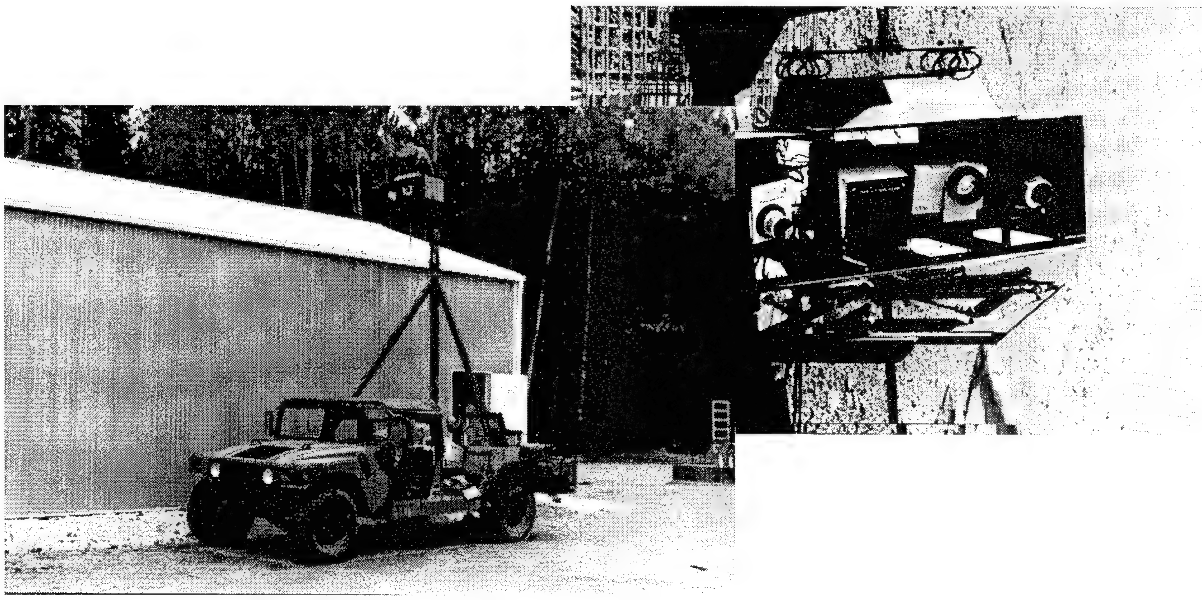
g. How good is the quality of the video that is transmitted back to the command station? What is the quality of the images that are transmitted to the command station? Can the shape of the buried device be determined? The image quality of the IR cameras was excellent considering that ideal light and temperature conditions were nonexistent during the test. Performance of the UV camera was good. The 2D image quality was good, however it was sometimes difficult to accurately determine the size and shape of the buried object or hole. Occasionally a major shift or sudden movement of the system and the GPR assembly would produce an object-like image on the screen. This is a software problem that can be corrected.

h. How accurately (distance from each mine in feet) does the marking system mark the objects it detects using the GPR sensor? Software problems and limited test time precluded an evaluation of the marking system. Detections were marked by hand.

i. How rugged is the system and how often does the system need repair (Operation time versus down time)? The system is rugged in that it holds up well during transportation and movement during operation. However it did not do well from a maintainability standpoint. Frequent software problems prevented the system from working until fixed by the contractor. The system's electronic components are not protected against the rain, which prevented it from being used in wet weather. Minor hardware problems occurred frequently. It was a challenge to keep the system in operation. During the demonstration it took a team of experts in computer software, hardware, GPR, IR and UV cameras and GPS to operate the system and keep it running.

j. How accurately does the GIS display on the lap top computer show the vehicle path as well as the location of marked targets? The GIS display is operated from a personal computer at the control center. It is very easy to operate and accurately displays the vehicle path and vehicle coordinates that are received from the GPS, and the IR/UV and GPR detections received from the target recognition software. The GIS display also allows the operator to view an overhead shot of the VMMD system or a wide angle view of the GPR array in front of the vehicle. All red (GPR) detections that appear on the GIS display are marked for inspection. The control station operator then looks for orange (IR or UV) and red (GPR) detections at the same location or coordinate. This indicates that the IR or UV camera detected a mine-like object and the GPR sensor confirmed that detection.

Ground Based Quality Assurance



1. The Ground Based Quality Assurance system is an integrated camera suite to detect mines. Refer to paragraph (A)(3) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section I, paragraph C.

2. Performance Evaluation: The ground based QA system was not completed in time to be tested. The system will be tested during 2QFY96 / 3QFY96.

3. The system did arrive before the test period ended and was able to provide a brief demonstration of its capabilities. Since the demonstration was not part of the formal test, it is not linked to any of the measures of success in the test plan. The system demonstrated that an operator can manipulate each camera to focus on areas of interest, capture images to a computer disk and enhance these images to manually detect surface mines. The system also successfully demonstrated automatic target recognition for surface mines.

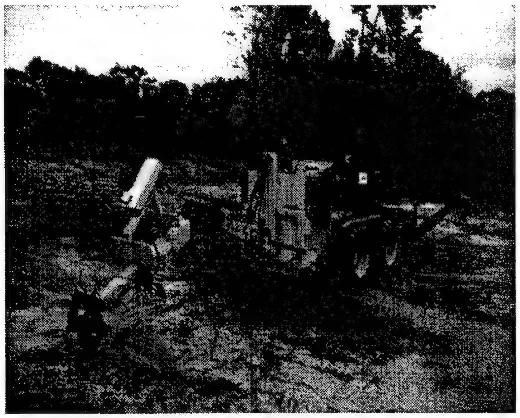
4. The system integration process identified the following areas for improvement:

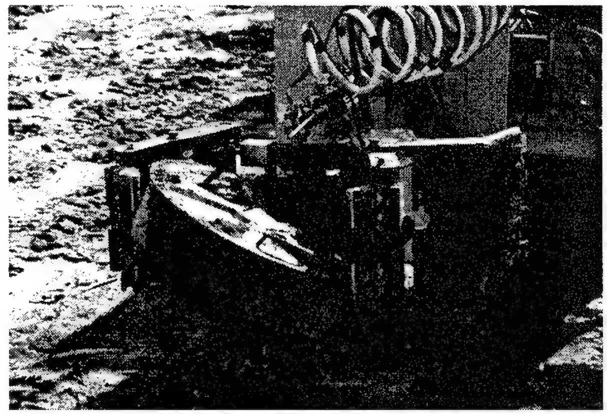
a. The mast used to attach the camera platform to the host vehicle is difficult and time consuming to erect. The process requires several people and a forklift to accomplish.

b. Once installed, the camera platform oscillated heavily when the vehicle moved. This required the host vehicle to travel very slowly (between 5 and 10 mph) to avoid damage to the cameras.

II. Mine Clearers:

Teleoperated Ordnance Disposal System (TODS)





1. The TODS concept adds mechanical mine clearance capability to an off-the-shelf skid loader. Refer to paragraph (B)(1) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section II, paragraph A.

2. Performance Evaluation:

In general the operators of the TODS were effective at remotely excavating land mines buried in hard and soft soils, and also at remotely clearing heavy vegetation so mine detection devices could search the area.

a. Was the metal detector useful in pinpointing the exact location of the marked mines? The metal detector was tested on five mines and had difficulty due to interference with the metal components of the mount and the digging arm. Once the detector head was moved more than three feet from the steel excavation arm, the system was able to detect mines.

b. How effective was the video system as an aid to excavating the mines? The video system was an effective aid as long as the mine location is properly marked. Testers initially marked the target mine locations with a small "X" painted on the ground. When it started to dig, the TODS eliminated the paint marker which caused the operator to loose his place. Once operators learned to increase the size of the "X" there were no further problems. This lesson learned will be included in the training program should this system be deployed.

c. Can the TODS remove mines from the ground without detonation? The TODS was able to easily remove anti-tank mines without detonating them. Not enough anti-personnel mines were tested and this needs to be addressed in the follow-on demining program.

d. Is the grass cutter able to trim grass and light brush to allow access to ground emplaced and buried mines? What obstacles or conditions affect the cutter operation? The grass cutter attachment demonstrated its ability in three mission scenarios. The first was to clear a 20m by 30m area containing high grass, weeds and small trees. This area was successfully cleared with no operator line of sight in about 30 minutes. The second

was to clear the side of a hill suspected of having anti-personnel mines. It had a sloping bank covered with high grass. Operators had difficulty at first determining if the placement of the cutter was flat on the bank, but as they gained experience were able to successfully complete the mission in about 45 minutes. The third was to clear a simulated off road area of heavy brush with varying terrain. This area was successfully cleared within 30 minutes so that off-road detection devices could be brought in to search for mines. Once operators were familiar with the display and the mechanics of the grass cutter, they had no difficulty in clearing any of these areas. Testers found it best to remove the mine locating and clearing arm while grass cutting so that it did not come in contact with the ground on the far side of the vehicle.

e. What mines does the air knife detonate, and at what range? Very limited testing was conducted with the air knife and further evaluation in the follow-on demining program is required.

f. What is the maximum weight the TODS is able to lift or drag? The pressure relief for the gripper arm was set at 50 pounds to avoid crushing the top of anti-tank mines and activating the fuzes. This limit was measured and worked successfully. The limit can be reset as needed.

Qualitative measures:

a. In which area did the system work the best? The system worked equally well in all areas, including digging out deeply buried anti-tank mines.

b. Did one team do significantly better than the other? Once operators were familiar with the system, there was no significant difference in performance between teams.

c. How easy is the TODS to set up, operate and maintain? How many hours of training are required? The system is simple to use. Operators become more effective with experience. Approximately 15 minutes of training is needed for an operator to begin.

d. What are the possible safety hazards if any, that may occur when operating the equipment? There are no specific safety concerns with this equipment. Personnel should be kept away from the equipment when the engine is running as with any remotely operated machinery.

e. How rugged is the system and how often does the system need repaired? The system had numerous break downs and is not ready to be fielded However, as the test progressed the bugs were worked out of the machine and the system operated reliably for 6 hours at a time.

f. How accurately does the GPS display on the lap top computer show the vehicle path as well as the location of marked targets? The GPS did not function properly during the test, but this capability needs to be expanded in the follow-on demining program.

Mini-flail

1. The Mini-flail is a small remote control anti-personnel mine clearer. Refer to paragraph (B)(2) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section II, paragraph B. The measures of success pertain to the mini-flail's ability to clear anti-personnel mines without activating anti-tank mines, its ability to negotiate obstacles and to how well it is suited for the humanitarian demining environment.

2. Performance Evaluation: Except for new wheels, the improved mini-flail was not completed in time to be tested. Explosive testing of the wheels did take place, and demonstrated they will survive any known pressure fuzed blast anti-personnel mine and will diminish shock / blast damage to the flail vehicle. The improved mini-flail will be tested in FY96 to answer the measures of success as stated in Appendix D of the Test Plan.

III. In-Situ Neutralization:

Explosive Demining Device (EDD)

1. The EDD is a shaped charge design for neutralization of mines in-situ. Refer to paragraph (C)(1) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section III, paragraph A.

2. Performance Evaluation:

a. How effective is the EDD against plastic, metallic and wooden AP mines?

(1) The Explosive Demining Device successfully neutralized metallic, wooden and plastic anti-personnel mines (M16, PMD-6 and M14 respectively). Nine mines were shallow buried (defined as the mine in the ground, its top flush with the surface and exposed). One mine of each type was buried to a depth of one inch. With the exception of one M16, all detonations were high order. The low order detonation on the M16 did destroy the mine. Testers therefore graded it as a successful kill. The EDD demonstrated the ability to penetrate the ground to depths of up to 22 inches. This indicates that the EDD may have the potential to neutralize mines buried to considerable depths.

(2) The system demonstrated anti-tank mine neutralization capability by destroying all four targets with high-order detonations. The mines were two M-19s, one TM-62 and one M15.

b. Is the EDD highly stable in storage and in transit, and able to withstand normal handling? The EDD is sufficiently stable to be stored and moved as a class 1.1D explosive.

c. Is the EDD simple to operate? Test personnel found the EDD simple to operate. It is easy to train host nation deminers to use this system.

d. Are there any human factors issues with the EDD?

(1) SOF testers prefer an adjustable tripod with a top that can be rotated. This would make aiming the device much simpler than with the current fixed tripod.

(2) The EDD cannot be electrically detonated. SOF testers want the capability to detonate the shaped charges using either non-electric caps, electric caps or detonation cord. They feel more comfortable with electric caps, which they consider to be safer for humanitarian demining. SOF representatives also expressed a need for multiple charges to match different size mines.

e. Is the EDD suitable for use in the humanitarian demining environment?

(1) The EDD is well suited for humanitarian demining with the understanding that it is a shaped charge and could be used as ammunition. The EDD, although very effective at destroying mines, may not be suitable for host nations where there is doubt over the intentions of the indigenous demining force.

(2) If produced in large quantities the EDD would be more cost effective than standard Army demolitions.

LEXFOAM

1. LEXFOAM is an explosive foam to destroy mines in-place. Refer to paragraph (C)(2) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section III, paragraph B.

2. Performance Evaluation:

a. Can LEXFOAM destroy or render permanently unusable 100% of the surface emplaced mines against which the technology is applied? LEXFOAM successfully neutralized all 19 target mines. These mines included both blast and fragmentation types. Fifteen of the mines were anti-personnel, consisting of the VS-50, PMD-6, OZM-72, M16 and M14 types. Four of the mines were anti-tank. Three of the AT mines were metallic (one M15 and two TM-62Ms) and one was plastic (M-19).This test demonstrated that LEXFOAM is effective against metal, plastic and wooden AP mines.

b. How many mines can be engaged with a single charging of the system? The backpack system provided enough foam to neutralize nine anti-tank mines before it had to be refilled. This number will vary in actual practice depending on the size of the mines and the number that are detonated simultaneously.

c. How long does it take to recharge/reload the system? The reload time was approximately 20 minutes. SOF testers expect this time to decrease as operators gain experience.

d. Are the instructions adequate? The printed instructions are adequate. Testers requested a video training tape to reinforce the printed instructions.

e. Is LEXFOAM simple to operate and maintain given the humanitarian demining situation? LEXFOAM proved to be easy to operate and maintain. In periods of heavy rain, LEXFOAM will loose its ability to detonate approximately 10 minutes after being dispensed. It is mentioned here for planning purposes. A water supply is necessary to clean the system. The need for a water source and for propane and nitrogen must be considered before deploying LEXFOAM.

f. Is LEXFOAM safe for deminers to use in humanitarian demining situations? Testers gave LEXFOAM high marks for safety, mostly because it is not explosive until the

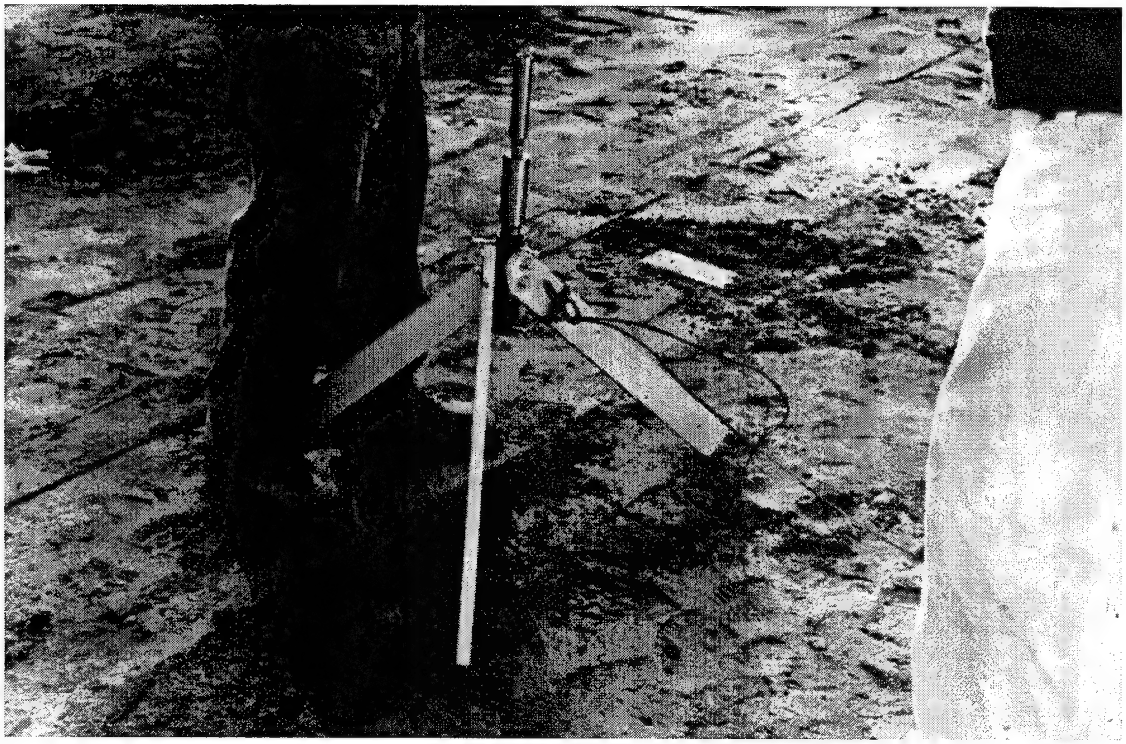
chemicals are mixed at the demining site. When in an unmixed state, the chemicals must be handled as flammable liquids.

g. Are there any human factors concerns with the use of LEXFOAM? Testers made the following suggestions to improve the LEXFOAM system:

(1) A lighter back pack.
(2) A more flexible recovery hose.
(3) A Velcro snap to hold the trigger gun down.
(4) The detonating sleeve holder needs to be larger.
(5) The palletized version should be lighter and smaller to permit it to fit into a small 1/2 ton pick-up truck, but still able to dispense the same quantity of explosive.
(6) The manual drum pump should be automatic.

h. Is LEXFOAM suitable for use in the humanitarian demining environment? SOF testers considered LEXFOAM to be well suited for humanitarian demining. Very good operating instructions mitigate the complicated set-up process. SOF testers had no difficulty setting-up and using the system. SOF test personnel consider LEXFOAM to be less expensive when compared to current standard demolitions. Another potential benefit is that the LEXFOAM system is less usable by terrorist activities.

Chemical Neutralization of Landmines



1. This in-situ neutralization approach tested three alternative chemical compounds and two different delivery techniques. Refer to paragraph (C)(3) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section III, paragraph C.

2. Performance Evaluation:

a. Can each chemical technique successfully neutralize plastic, metal and wood AP and AT mines to which the technology is applied?

(1) Diethylenetriamine in capsule form using Gun 1 (bullet fired through a chemical filled capsule and into the mine) against AP mines: This test took place against 9 mines, 3 of which were fuzed. Target mines were as follows:

Case Material:	Metal	Plastic	Wood
Mine:	M16	PMN-2	PMD-6
Quantity:	3	3	3

This combination of chemical and delivery system neutralized all nine mines. Testers expected a high order detonation with the fuzed mines due to heat generated by the burning process. This did not occur. Both fuzed and unfuzed mines burned for 5 to 7 minutes with no visible flame. Another surprise was that the cases of the plastic and wooden mines did not burn, even though all of the explosive material did.

(2) Diethylzinc using Gun 2 (chemical filled bullet) against AP mines: The target mine population was the same as described above except that there were 2 PMD-6s. One of the eight mines (an M16) was neutralized. Partial burning took place in the other seven mines. The cartridges successfully penetrated the mine casing. but not enough of the chemical penetrated the wrapping paper around the TNT blocks. This resulted in the partial burning.

(3) Diethylenetriamine in capsule form using Gun 1 against AT mines: There were four target mines in this test. One plastic M-19, one wooden TMD-44 and two metallic M15s. All four mines were successfully neutralized. The M-19 burned for 60 minutes with a visible flame.

(4) Diethylzinc in cartridge form using Gun 2 against AT mines: Target mines were identical to the previous test. The M-19, which burned with a visible flame for 60 minutes, was the only mine successfully neutralized. Failures with the TMD-44 and the M15 (with and without cap) occurred because the chemical filled bullet failed to penetrate the wood and metal cases of the mines.

(5) Brominetriflouride (neutralization by deflagration/detonation of RDX): Six VS-50 mines were the targets for this test. Gun 1 delivered the chemical to three of the mines and Gun 2 operated against the other three. Both delivery systems penetrated the mine cases but the chemical failed to react with the RDX in the mines. The contractor used pure RDX for their pre-test with this formula. The RDX in the VS-50, however, includes a binder material that prevented a reaction.

b. Are there any environmental considerations associated with the use of chemicals for in-situ neutralization (for example, are any of the chemicals considered to be pollutants)? There are no environmental impacts associated with this system. The amount of chemicals used is very small and they are consumed in the neutralization process. The chemicals have special storage and handling requirements that must be followed.

c. How many mines can the chemical techniques successfully be applied to in one workday, taking safe working area requirements into account? A trained crew can neutralize an average of 10 anti-tank or 20 anti-personnel mines in one day.

d. Are there any safety concerns regarding chemical neutralization technology?

(1) Test personnel expressed concern with neutralization methods that use low order detonation. High order detonation is certain proof of destruction. Deminers lack confidence that a mine is safely neutralized after completion of the burning process.

(2) The long term stability of the chemicals in the cartridges is unknown. This should be defined, and appropriate safety procedures should be developed prior to distributing a chemical neutralization system.

(3) Rubber hand gloves and safety glasses should be used during loading of the chemical capsules or chemical cartridges in the delivery system.

(4) Normal cautions and procedures associated with these chemicals should be followed.

e. Are there any human factors issues with chemical neutralization technology? Application of the chemical and delivery systems is not difficult. However, the diethylzinc system requires special transportation and storage requirements, and an extremely detailed knowledge of mine characteristics. The chemicals must be tailor mixed depending on mine case thickness. Deminers must therefore know the exact mine that they are attempting to

neutralize, and what formula mix to use on it. The special handling and storage requirements increases the complexity of this system in austere host nations. The infrastructure in many host nations may not be able to meet the storage requirements. Training and use for uneducated host nation people will be very difficult.

f. Is the chemical neutralization approach to in-situ neutralization suitable for the humanitarian demining environment? Chemical neutralization has the potential be a viable neutralization option. The benefit to a system that destroys mines without leaving fragments is significant. SOF representatives stated that the following improvements would be pre-requisites to the introduction of chemical neutralization for humanitarian demining:

(1) There should be one chemical and one delivery system to neutralize all mines.

(2) The need for special storage and handling requirements should be eliminated.

(3) The system should be simple, inexpensive and disposable. The current system is too big, too bulky and too heavy.

Mine Marking and Neutralization

1. The Mine Marking and Neutralization Foam is a two part liquid that produces a hard foam after it is applied to a mine, and renders the mine inoperative. Refer to paragraph (C)(4) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section III, paragraph D.

2. Performance Evaluation:

The table below summarizes the quantitative parameters measured during 26 separate tests run on the mine marking foam during the Ft. A. P. Hill demonstration. The complete text of the test results are provided in Appendix 2.

Ft. A. P. Hill demonstration quantitative parameter data summary.

Dispense Time: Gun: 1:50-3:45 min. depending on foam storage temperature. Hand Mix: 30 sec - 1:45 min. depending on foam temp and observer		
Time to Begin to Foam Gun: 1:30 - 3:00 minutes Hand Mix - 0:10 - 3:10	Time to Gel: Gun: 3:00 - 7:00 minutes Hand Mix 3:00 - 6:00	Tack Free Time: 4:00 - 11:00 minutes
Time to Harden: 4:00-11:20 minutes	Height: 3 - 7 inches	Diameter: 8 - 18 inches

a. Does the foam encase the mine without causing it to detonate (this includes mines with anti-handling devices)? The foam is able to cover both simple pressure and

tripwire fused anti-personnel land mines. The foam has sufficient ratio of rise time to gel time to allow it to be poured around a mine and encase the top before hardening begins. The material is also formulated so that the deminer has time to leave the immediate area of the mine before foaming begins.

b. Does the foam prevent mines from detonating after neutralization?

(1) All of the foamed mines were tested to insure that if a deminer accidentally stepped on a treated mine it would not activate. Of the twenty mines tested, only two activated. Both of these seemed to be because not enough of the foam was allowed to foam over the top and freeze the activation mechanism. These deficiencies can be corrected with operator training.

(2) The mine foam was capable of distributing loads applied to AP mines in the places where they were exposed and their tops or triggering mechanisms were completely covered by foam. In some cases, however, it was possible to trip the mines once they were pulled from the ground and then jumped on with one or both feet or where a pressure trigger was not fully encapsulated. Otherwise, all of the foamed mines were strong/rigid enough to withstand standing on without activation.

c. Does the foam adhere to trip wires to preclude tension release fuses from functioning? The foam fills interior spaces in trigger mechanisms and freezes trip wire activation pins to prevent them from functioning.

d. Does the foam adhere to pull cords as well as the mines so that a deminer can remove a suspected booby trapped mines from a safe distance? Several types of cords were tested and the foam is sufficiently adhesive to all types of cords. The deminers learned through testing that a knot should always be tied in the cord to provide enough surface area for the foam to adhere. The mines encased in foam were dragged to a demolition pit and destroyed using standard demining charges. The foam adhered well enough to metal and plastic surfaces, even when they were cold, wet, and dirty, that they could be pulled out of the ground from a distance using a rope. While the foam did adhere to most of the wooden box mines, it appeared that it was the amount of mine surface exposed prior to applying the foam that was more critical for this type of mine

e. Does the foam perform effectively in all soil types and climactic conditions?

(1) The foam functioned similarly in all environments, temperature ranges and soil types. The foaming reaction is slower in colder weather but still is complete within 20 minutes.

(2) Because of the difficulty of using the dispensing gun in cold temperatures, it was decided in some cases to not use the mixing tip and gun for mixing. Instead, testers used the mixing tip to push the cartridge contents into the foil kit bag. They then stirred and mixed the foam chemicals in the bag, and poured the liquid mix onto the mine. This worked very well, and was actually faster than using the mixing tip and gun. SOF testers liked the consistency and texture of the bag-mixed foam as well or better than when the foam was dispensed from the gun. They had no objection to using the bag as a mixing pouch, and suggested that this option be included in the instruction sheet.

f. Is the foam dispensing system simple and easy to use? The foam system package includes a photo instruction card and is simple enough to use that most operators were able to use the product without reading any directions. The systems is especially robust in that field expedient mixing without proper tools proved to be just as safe, effective and reliable as with the dispenser.

field expedient mixing without proper tools proved to be just as safe, effective and reliable as with the dispenser.

g. Are there any toxic effects associated with the polyurethane foam? The foam is environmentally benign in the hardened marking state and after destruction by demolition. The destruction of the foam does not produce any toxic contamination of the soil. All the materials are inert after the reaction is complete. All pertinent safety information is contained on the labels of the product. Also, a safety hazard analysis has been completed and included as an appendix in the data section of the contractor report.

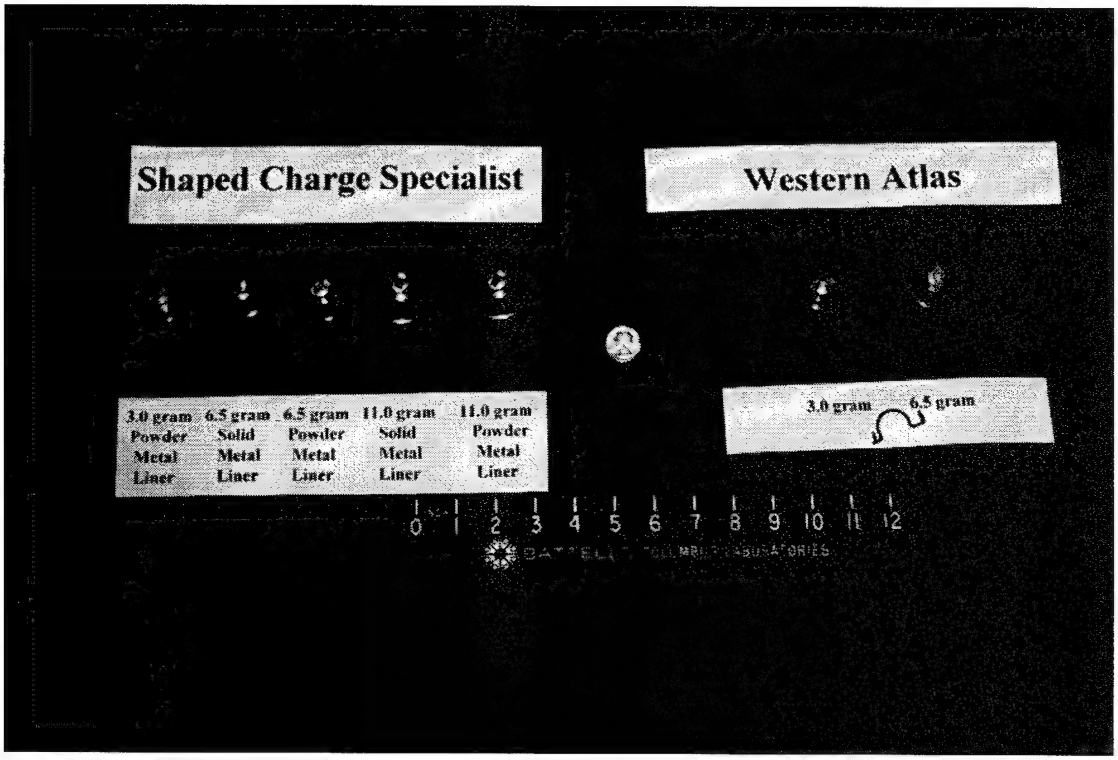
h. Does the foam withstand the effects of wet, freezing, arid, etc. weather without disintegrating? The foam functions consistently in dry or humid conditions, and in cold or hot weather conditions. The only noticeable change is that the foaming reaction is slower in colder weather. For example the rise time at 70 degrees F is three minutes. At 32 degrees F it is about six minutes. The hardening time increases from 10 minutes to 20 minutes.

i. Are there any safety of use problems associated with the mine marking and neutralization system? There are no major safety issues. Rubber gloves are included with each package to prevent exposure to the un-reacted chemicals and all pertinent safety information is contained on the labels on the product. Should the un-reacted isocyanate come in contact with skin, it can be washed off with alcohol or vigorous scrubbing under running water.

j. Are there any human factors issues associated with the dispensing system or the chemical foam at any time before, during or after application? Operators had some difficulty dispensing the liquid components of the foam when using the caulking gun in cold weather conditions. This can be remedied by using a different dispensing system or by mixing the materials by hand as described above. Using the improvised hand mix also reduces the time the operator is near the mine and generally provided a better mixed solution.

k. Is the mine marking and neutralization system suitable for use in the humanitarian demining environment? The foam is ready for immediate use in humanitarian demining.

Shaped Charges



1. The application of commercial oil well bore hole charges to demining. Refer to paragraph (C)(5) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan in Appendix D, Section III, paragraph E.

2. Performance Evaluation:

a. Can the shaped charges destroy 100% of the mines against which they are applied? These commercially available charges performed successfully against 12 anti-personnel and 4 anti-tank mines. Anti-personnel mine targets were:

Case Material:	Metal	Plastic	Plastic	Wood
Mine:	M16	M14	VS-50	PMD-6
Quantity:	3	3	2	4

(1) There were three sizes of shaped charges at the OCDT: 3gm, 6.5gm and 11gm. Charges of the 3gm and 6.5gm sizes performed successfully against all of the above mines. One M16 was destroyed by one 11gm charge.

(2) The AT mines were one M-19, one TM-62 and two M15s. The M-19 is plastic and the others are metal. The 6.5gm charge successfully destroyed all four mines.

b. Are the shaped charges stable in storage and in transit, and able to withstand normal handling considering the humanitarian demining environment? There are no problems with this system. It is handled as an ammunition item.

c. Are the shaped charges safe for deminers to use in humanitarian demining situations? SOF testers expressed concern over the attachment device used to set the charge over the mine. It requires the user to physically tape the stand-off device to the live mine. A stand-off method that allows set-up without touching the mine is needed should this neutralization alternative be deployed.

IV. Individual Components:

Modular Vehicle Protection (MVP) Kit

1. The MVP is a mine detonation protection kit designed for commercial vehicles. Refer to paragraph (D)(1)(a) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph A.

2. Performance Evaluation:

a. Can the MVP kit withstand the effects (penetration or plastic deformation of the crew compartment) of M16A2, M18A1, PMN and POMZ-2M mines? Testers fired one 1/2 lb. block of TNT, three anti-personnel mines (OZM-72, M16 and MON-50) and two VS-1.6 anti-tank mines against the hardened vehicle. The OZM-72 and the M16 are metal bounding fragmentation mines. The MON-50 is a directed fragmentation mine similar to the US M18 Claymore. The VS-1.6 is a plastic light anti-tank mine. Although the MVP requirement is only to protect vehicle occupants from the effects of AP mines, the AT test was performed to gather information. The following table summarizes the results:

Mine	Probable Crew Injury *	Vehicle Damage
1/2 lb. TNT	None.	Flat tire, bent rim.
OZM-72	N/A	None - mine detonated in the ground.
M16	Fatal - primary fragmentation injuries to driver, minor blast and secondary fragmentation	- Deflector cut. - Floor deflections and venting. - Side armor installed to left of driver's feet, directly in front of the door, dislodged and

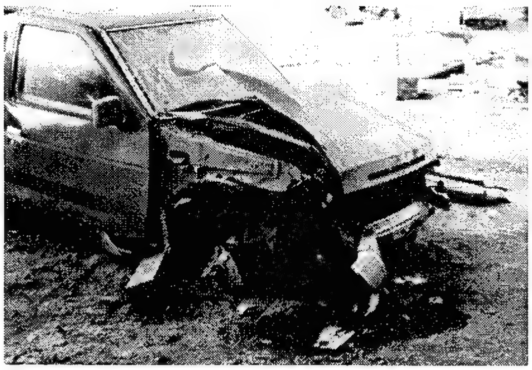
Mine	Probable Crew Injury *	Vehicle Damage
	injuries to remaining occupants.	rotated up and into the driver's feet and legs. - Probable engine damage.
MON-50	Severe to fatal injuries due to primary fragmentation.	- Over 50 penetrations from 249 fragment strikes to the vehicle. - Fuel tank punctured. - Both left tires flat.
VS-1.6 (under right front tire)	Non-fatal injuries to all occupants due to blast and acceleration.	- Non-repairable damage. - Right quarter panel blown four feet from vehicle. - Windshield knocked loose. - Minor venting (blast effect) through the dash. - Armor panel knocked loose. - Severe engine damage.
VS-1.6 (under left rear tire)	Severe to fatal injuries due to blast, acceleration and secondary fragmentation.	- Non-repairable damage. - Left rear quarter panel gone. - Severe venting (blast effect).

* Engineer's assessment based on shot line analysis, local deformation and other relevant damage.

Fatal injuries to the vehicle occupants would have resulted from the M16, the MON-50 and one of the VS-1.6 detonations. The reason for this performance is not because the armor failed to function, but because the armor installation did not fully protect the crew compartment. The installation left gaps in coverage through which shrapnel and blast effect penetrated the cab.

b. Can the MVP kit limit damage caused by AP mines to the vehicle such that tire replacement and engine compartment repairs are the only repair needed to continue the demining mission? The armor held up well when subjected to a 1/2 lb. blast of TNT under a wheel. There was no damage to the crew compartment.

Blast Protected Vehicle



1. The BPV is a mine detonation protection kit designed for commercial vehicles. Refer to paragraph (D)(1)(b) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system is in the Test Plan in Appendix D, Section IV, paragraph B.

2. Performance Evaluation:

Can the vehicle armor kit withstand the effects of M16A2, M18A1, POMZ-2M and PMN mines without penetration or plastic deformation of the crew compartment?

The table below summarizes the various blasts that each vehicle underwent and the results.

Vehicle	Type of mine or TNT	Probable Crew Injuries *	Vehicle Damage
Toyota	1/2 lb. TNT block	None	tire, quarter panel blown off.
	1/2 lb. TNT block	None	tire, quarter panel blown off.
	1 lb. TNT block	None	tire blown off.
	1.5 lb. TNT block	None	Underbelly armor stand-offs deformed.
	M16	Severe primary fragmentation injuries.	Major damage w/fragments entering the crew compartment.
	POMZ-2M	None	62 hits on sheet metal, 22 of which penetrated the sheet metal. No penetration into the crew compartment. 14 window hits with no penetrations.
	M18 Claymore	Driver - minor primary fragmentation injuries.	The vehicle was hit 423 times by claymore pellets. 6 penetrated through the door.

Vehicle	Type of mine or TNT	Probable Crew Injuries *	Vehicle Damage
		Passenger - killed by primary fragmentation.	
Nissan	1/2 lb. TNT block	None	Tire blown off, quarter panel loosened.
	VS-1.6	Acceleration injuries, minor cuts by secondary fragmentation.	Wheel, quarter panel blown off - hood loose, cab perforated, windows popped.
	1 lb. TNT block	None	Tire destroyed, fasteners pulled out of conveyer belt underbody.
	M16	None	Damage to door, tire and probable damage to engine compartment.
	M18 underbelly	None	Fiberglass armor perforated, heavily damaged transmission, ceramically bonded cement (CBC) not penetrated.
	POMZ-2M	None	143 hits with 25 partial penetrations. 23 window hits with no penetrations.
	M18	Driver - severe leg injuries caused by primary fragmentation. Passenger - killed by primary fragmentation.	The vehicle was hit 350 times by claymore pellets. There were 11 penetrations through the door and 5 through the window.

* Engineer's assessment based on shot line analysis, local deformation and other relevant damage.

This system performed well. Testers attribute the Nissan's success against the first M18 to the transmission, which probably absorbed much of the fragments and the blast force. The second M18 detonation produced results more closely resembling the Toyota.

Mobile Training System

1. The Mobile Training System provides mine awareness training to host nation people. Refer to paragraph (D)(2) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph C.

2. Performance Evaluation: The vehicle based mobile training system was not tested. However, SOF personnel did witness a demonstration of the suitcase version and were impressed. They feel that this system would greatly enhance their effectiveness when conducting demining missions. The suitcase trainer demonstrated the following capabilities:

a. The ability to print large graphic training aids as posters and to support classroom training.

b. It prints mine awareness messages on T-shirts or any cloth material that would be used in mine awareness classes.

c. The system can play multi-lingual demining films.

d. It will provide mine facts and information on over 650 mines. This is extremely valuable for anyone conducting demining operations.

Mini Mine Detector

1. The Mini Mine Detector (MMD) is a battery powered, hand held, miniature metal detector. Refer to paragraph (D)(3) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures for success for this system appears in the Test Plan in Appendix D, Section IV, Paragraph D.

2. Performance Evaluation:

a. Is the Mini Mine Detector performance equal to or better than the PSS-12?

(1) The current US military standard mine detector is the AN-19 PSS-12. This mine detector was used as the standard for the evaluation of the mine detection capability of the MMD. The MMD performed almost identically to the PSS-12 mine detector in all of the areas tested. Five units were tested, and all had the same detection performance.

(2) The MMD units were tested in a variety of weather conditions including cold weather, warm weather, rain, dry soil and sand, and wet soil and sand. The units worked similarly under all conditions.

b. How much does the Mini Mine Detector weigh with batteries? The design goal was to build units of less than four pounds so that a deminer could operate for long periods of time without fatigue caused by the weight of the detector. The MMD weighs 3.2 pounds with batteries.

c. Can the Mini Mine Detector, when folded, fit into the Battle Dress Uniform (BDU) pocket? The BDU pocket size was chosen as the design goal because host nation demining crews generally have similar uniforms. The MMD can be carried in the pocket on the leg of the uniform, with part protruding out the top of the pocket.

d. What is the endurance of the Mini Mine Detector with standard AA batteries? The MMD will operate from 10 to 20 hours on four AA batteries, depending on the temperature. Cold weather reduces battery performance.

e. Are there any safety of use problems or human factors issues that require improvement prior to using the Mini Mine Detector in a humanitarian demining environment? SOF representatives suggested the following human factor related improvements for the Mini Mine Detector:

(1) Improve the handle configuration so that the MMD is easily useable when the operator is standing or lying.

(2) Add fixed adjustment points to the detection head to keep it steady during operation.

(3) Extend battery life for long term demining operations by adding a small solar powered charger into the handle to permit battery charging while the unit is in use.

(4) Add a test chip to the detector bag to calibrate the detector.

(5) Add an extra earphone to the detector bag.

Extended Length Probe

1. Description: The purpose of the extended length "smart" probe is to improve efficiency and safety for deminers as they manually probe for mines. It does so by allowing the deminer to search an area from further away, and identify buried objects that the probe contacts. Refer to paragraph (D)(4) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures for success for this system appears in the Test Plan in Appendix D, Section IV, Paragraph E.

2. Performance Evaluation:

a. Does the extended length probe enable the operator to pinpoint subsurface mines buried up to five (5) inches deep and no closer than two (2) meters away from the operator? The probe can pinpoint buried objects two meters away and 6 inches deep.

b. Does the vibrator tip microphone allow the operator to discriminate between objects to determine potential mines with 100% accuracy, accepting false positives? Design engineers and SOF representatives who worked with the probe during the test were able, after some practice, to distinguish what type of mine casing that they were probing.

c. Will the blast shield protect the operator from mine explosions up to equivalent power of the PMN? The blast protection capabilities will be assessed in future demining work.

d. Is the extended length probe able to withstand normal operations without noticeable damage? There was no damage to the probe during testing.

e. Are there any safety concerns regarding the extended length probe? SOF testers expressed concern that the probe tip must come into contact with the mine, possibly detonating it. This criteria needs further evaluation in the follow-on demining program.

f. Are there any human factors issues with the extended length probe? This criteria needs further evaluation in the follow-on demining program.

g. Is the extended length probe generally suitable for operations in the humanitarian demining environment? This criteria needs further evaluation in the follow-on demining program.

Extended Length Weedeater

1. The extended length weedeater is a handheld or wheel mounted vegetation cutter with a long shaft. Refer to paragraph (D)(5) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph F.

2. Performance Evaluation:

<u>Hand Held Weedeater:</u>

a. Is the operator able to remove vegetation to the front and sides? The hand held extended length weedeater demonstrated the ability to clear vegetation up to 8 feet in front and to the sides of the operator in approximately a 160 degree arc.

b. Is the system able to cut various types of vegetation? Testing was conducted in three areas using SOF operators. The first area was a dry overgrown swamp with very dense tall grass approximately 4 feet high. The second area was an open field covered with grass and weeds varying in height from 6 inches to 12 inches. The third area was an overgrown woodlands area that had large mature trees, small saplings and forest vegetation ground cover. Testers were able to cut various heights and density of grass in all of the areas. However, the taller and denser the vegetation the slower the operator had to go. In very tall grass in the swamp the operators had to start at the top of the grass and work their way down cutting about 12 inches at a time. In the woodlands area it was necessary to change the cutting head from a line cutting head to a brush cutting blade head. This change took about 2 minutes. The weedeater with brush cutting head was successful at cutting small trees up to 1 inch in diameter. The weedeater cut grass down to a height of approximately one inch and could cut vegetation flush with the ground if required. The weedeater required frequent manual feeding of the cutting line, which was time consuming. The prototype extended the length of the shaft and not the angle of the cutting head. The cutting head is not properly orientated to the ground for the bump line feed feature to work.

c. Will the weedeater cut trip wires? The weedeater had problems with wire obstacles. Trip wires, even cut ones, tended to tangle with the weedeater, becoming trapped around the cutting head. This could detonate the mine that was attached to the tripwire.

d. Does the weedeater activate pressure fuzed mines while clearing vegetation? The prototype weedeater demonstrated the ability to remove vegetation over various types of pressure fuzed mines without activating the fuze. However, in its present configuration, it will detonate bounding fuzed mines, although the mine must be struck several times to activate the fuse

mechanism. A simple mechanical fix that acts like a height gauge will prevent the cutting line from reaching the fuzes of bounding mines. Also this device would be used in concert with grapnels, which would have disposed of tripwires and mines with trip wires.

e. Is there any noticeable wear/damage during normal operations? The hand held extended length weedeater did not experience any mechanical failures during the course of the test. The replacement of the cutting line is part of normal operations.

f. Are there any safety concerns regarding the extended length weedeater? SOF operators made the following comments regarding the safety of a hand held extended length weedeater.

-The device should incorporate a protective shield sufficient to stop earth, etc., fragments propelled by AP blast mines .

- It should not be used in areas where trip wires are present.
- Operators using the weedeater should continue to wear protective clothing.
- The extended length weedeater puts the operator a safe distance away from blast effects but not fragmentation effects of AP mines.

g. Are there any human factors issues with the extended length weedeater? SOF operators complained of fatigue due to the additional weight of the extended length of the weedeater. The system needs to be better balanced to limit operator fatigue.

h. Is the extended length weedeater generally suitable for operations in the humanitarian demining environment? SOF operators made the following comments/recommendations regarding the suitability of a hand held extended length weedeater.

- The weedeater is a valuable demining tool.
- Include the extended length weedeater in the deminers kit, and include its proper use in the training program for indigenous deminers.

Wheeled weedeater:

a. Is the operator able to clear vegetation to the front and to the sides? The wheeled weedeater could not cut in an arc. It was necessary to cut in straight lanes approximately 24 inches in diameter. The wheeled weedeater demonstrated the ability to cut vegetation 18 feet forward of the operator.

b. Is the system able to cut various types of vegetation? Testing was conducted in the same three areas as the hand held weedeater. The wheeled weedeater was not as versatile as the hand held version when cutting tall grass in the swamp area. The wheeled weedeater was not able to cut grass from the top down but would cut it off at the bottom. This resulted in 4 foot long grass stalks laying over the machine and surrounding ground further concealing the suspected mines. The long cut grass needed to be removed for the use of mine detectors. In the field area the wheeled weedeater demonstrated the ability to cut at a faster rate than the hand held weedeater. Testers found that the wheeled weedeater would not cut thick wooded vegetation and has no other optional cutting head available.

c. Will the weedeater cut trip wires? The wheeled weedeater had problems with wire obstacles. Trip wires, even cut ones, tended to tangle with the weedeater, becoming trapped around the cutting head. This would probably detonate the mine that was attached to the tripwire.

d. Does the weedeater activate pressure fuzed mines while clearing vegetation? The wheeled weedeater demonstrated the ability to remove vegetation over various

types of pressure fuzed mines, although the wheels on the system did detonate all the pressure fuzed mines used. The Wheeled weedeater would also detonate tripwire fuzed mines the same as the hand held version.

e. Is there any noticeable wear/damage during normal operations? The wheeled weedeater did not experience any mechanical failures during the course of the test other than the replacement of the cutting line which is normal.

f. Are there any safety concerns regarding the wheeled weedeater? SOF operators made the following comments regarding the safety of a wheeled weedeater:

- The ground pressure exerted by the wheels should be reduced.
- It should not be used in an area known to contain trip wires.

g. Are there any human factors issues with the wheeled weedeater? There were no human factor issues identified during this evaluation.

h. Is the wheeled weedeater generally suitable for operations in the humanitarian demining environment? SOF operators made the following comments/recommendations regarding the suitability of a wheeled weedeater:

-The wheeled weedeater is not as versatile a tool as the hand held version.
-There are situations that the wheeled weedeater is a valuable demining tool.

PSS-12 Mine Location Marker

1. A mine marking device that attaches to any open ring handheld mine detector. Refer to paragraph (D)(6) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph G.

2. Performance Evaluation:

a. Can the mine location marker be easily attached to the PSS-12 within 5 minutes? The PSS-12 mine location marker is easily attached using duct tape or wire ties. The sprayer is carried by the operator using the attached shoulder strap. The time to attach varied depending on the number of times performed. The longest time recorded was 8 minutes for a first attempt. Time improved to 5 minutes and less once installation procedures were refined.

b. Is the mine location marker readily adaptable to any handheld mine detector which has an open center ring? The Mine Location Marker is easily adaptable to the PSS-12 mine detector by attaching plastic extensions to the sprayer and positioning the outlet of the sprayer tip into the center ring.

c. Does the mine location marker degrade the performance of PSS-12? There is no degradation in performance of the mine detector because the sprayer tip and extension tube is plastic. Some overspray from the sprayer does get on the detector ring and shaft but does not effect performance.

d. How much does the mine location marker weigh, including the spray mechanism and air pack? The Mine Location Marker weighs 5 pounds including extension wands. The sprayer holds 1 gallon of water thinned latex paint which adds an additional 7 pounds.

e. Does the mine location marker mark suspected mine location with non-toxic chemical such that the mark remains visible for at least 5 days? Testers tried various types of water based paints for the mine marker. The best type found was bright colored latex paints thinned sufficiently for the sprayer to function properly (about 1 part paint to 1 part water). Weather, dew, frost, and the amount of paint used all affected the longevity of the mark. In fair weather conditions the mark remained visible for 5 days, although fading does start to occur after the first day and continues until the mark is gone (approx. 5 days).

f. Are there any safety concerns with the mine location marker? There were no safety concerns identified in the performance evaluation.

g. Are there any human factors concerns with the mine location marker? The additional 12 pounds that the mine location marker added to an operator will increase the increments of operator fatigue. This will result in revising the operators work/rest schedule, but time saved by eliminating a separate marking process outweighs the additional rest required by the operator.

h. What is the overall suitability of the mine location marker in the humanitarian demining environment? SOF testers concluded that the Mine Location Marker is time efficient and necessary to reduce the per mine cost of mine removal/neutralization.

Blast and Fragment Containers

1. The Blast and Fragment Container is a device that permits the destruction of mines in place while protecting high value assets. Refer to paragraph (D)(7) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph H.

2. Performance Evaluation:

a. How easy is the blast and fragment container to assemble? The blast and fragment container requires no assembly once it has been delivered. The cylindrical container is constructed of single length S2 glass dry rolled into 1 inch thickness weighing approximately 85 pounds.

b. Can the blast and fragment container be safely placed over a live in-place bounding or pressure fused mine? Although caution must be exercised, the blast and fragment container can be and was safely placed over bounding and pressure fuzed mines. These containers were simply rolled near the area they were to be placed or carried by two demining personnel. Once the container was located near the mine, a small trench about 15 inches long was dug leading up to the mine. The detonation cord was then stretched along the trench and the container placed over the mine. The blast and fragment containers were positioned over the mine, making sure not to pinch or sever the detonation cord. In a few of the detonations, LEXFOAM was used and was sprayed in the trench leading up to the mine. No problems occurred with either method. One other safety consideration is that when the shots using the containers are fired, the containers are blown into the air. Extreme care should be exercised just as it is with other standard EOD procedures.

c. What is the number of detonations from blast and fragmentation from antipersonnel mines that the containers can withstand?

(1) The blast and fragment containers can withstand between one and three detonations depending on the type of antipersonnel mine. Container #1 was approximately 18" in diameter and constructed of single length S2 glass dry rolled into a 2 inch thickness. This withstood the effects of 3 antipersonnel blast mines using between 500 and 1000 grams of LEXFOAM as the explosive on each shot. Four sandbags were placed around the container for extra support. An M14 was used for the first shot, which made a slight tear at one end of the container. This was presumably where the container was placed over the detonation cord. However, no interior damage was recorded. A VS-50 was used for the second shot. As a result of the blast, the inside seam started to delaminate. Also, a greater amount of LEXFOAM was used on this shot. A PMD-6 was used for the third shot. Severe delamination occurred as a result of this mine blast. Although no penetration occurred on this container, no more shots could be performed using this container.

(2) Containers #2, #3, and #4 were approximately 27" in diameter and were also constructed of single length S2 glass dry rolled into a 1 inch thick cylinder. These containers weighed between 85 and 90 pounds. Sandbags were used as additional support for the containers. Approximately 500 to 1000 grams of LEXFOAM was used as the explosive for container #2. Two blast antipersonnel mines and an M16 fragmentation antipersonnel mine were tested against container #2. The first blast mine detonated was the VS-50 which caused no interior or exterior damage to the blast and fragment container. The PMD-6 blast mine was used for the second live fire shot. Delamination was barely noticeable after this detonation. Since there was no major damage, an M16 fragmentation mine was used for the third shot. The container withstood the effects of this detonation and caught the fragments from the M16. No complete penetration of fragments was visible although delamination continued to occur. The delamination that occurred was severe enough to prevent a fourth live fire detonation on this container.

(3) Container # 3 was tested against a Valmara 69 using a block of C4 (approximately 1.25 pounds). Iron and steel sheets surrounded the blast and fragment container approximately 3 feet away, simulating a critical high value asset. It contained the fragmentation from the Valmara 69 and prevented fragments from hitting and penetrating the high value asset simulators (steel sheets).

(4) Finally, container #4 was tested against an M16 antipersonnel fragmentation mine. A shaped charge was used to set off the mine for this live fire detonation. No sand bags were used for this test. The container caught the majority of the fragments from the mine. However a slight tear occurred near the bottom of the container, possibly from the additional shrapnel created by the shape charge munition. It is not certain whether any fragments escaped during the explosion.

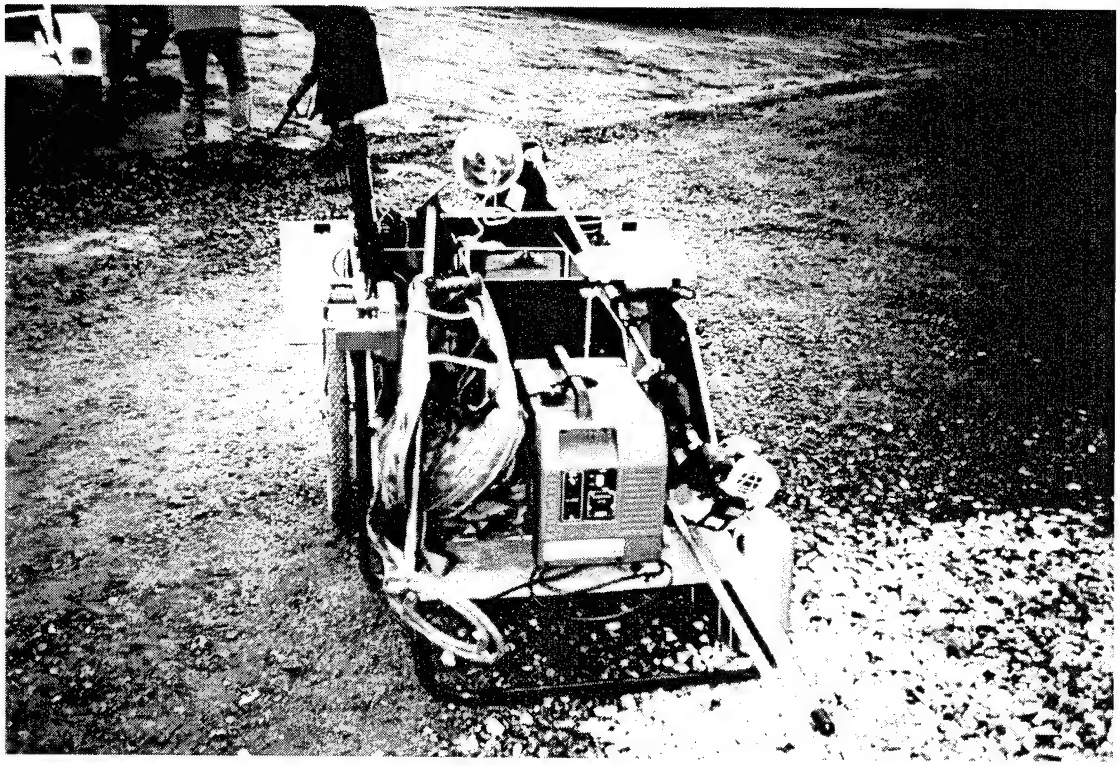
d. Does the Explosion container permit detonation of the mine without damage to a high value structure or object within three feet of the device?

(1) The 27" diameter blast and fragmentation container proved that it can contain the fragments from antipersonnel fragmentation mines and protect high value assets within three feet of the container. As stated above, Container #3 was tested against a Valmara 69 fragmentation mine using steel sheets as simulated high value assets located approximately three feet away. No fragments penetrated the blast and fragment container, nor did any escape during the blast and penetrate the steel sheets.

(2) Knowing this particular design would be successful in protecting high value assets, research could be performed to maximize the container's effectiveness while minimizing its cost and weight.

e. Are there any safety concerns using the blast and fragment containers? The only safety concern with the blast and fragment container is setting it over the mine before live fire detonation. The container is somewhat heavy and requires two men to perform this procedure safely. Standard EOD procedures should be followed.

Demining Kit



1. The demining kit consists of a hand cart with a collection of hand and power tools for demining. Refer to paragraph (D)(8) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan for this system appears in the Test Plan at Appendix D, Section IV, paragraph I.

2. Performance Evaluation:

a. Can the cart, with certain accessories in place, be manually pushed or pulled in difficult to reach terrain? Testers found it difficult to manually move the cart when fully loaded with tools, the light grapnel, the small generator and the protective armor. The generator's position at the rear of the cart aggravated the problem, but this location was necessary to counterbalance the weight of the armor on the front. Work to correct this problem is necessary. A second cart is a possible solution.

b. Does the armor attached to the front of the demining cart adequately protect the deminers and their equipment from the effects of an AP mine equivalent to the Valmara 69? Explosive testing of the demining kit protective armor is scheduled for FY96.

c. Is the demining cart adequate to support the launch and retrieval mechanism of the light grapnel? The demining cart withstood the force of the grapnel launch without damage. The cart remained stationary when the grapnel was launched and retrieved. This saved testers from having to re-aim the unit between launches.

d. Are there any safety concerns with the demining kit? There are no safety concerns with the demining kit. Normal safety procedures associated with the various tools that make up the kit should be followed.

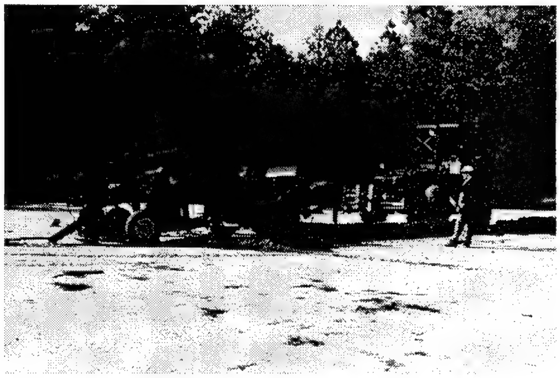
e. Are there any human factors concerns with the demining kit?

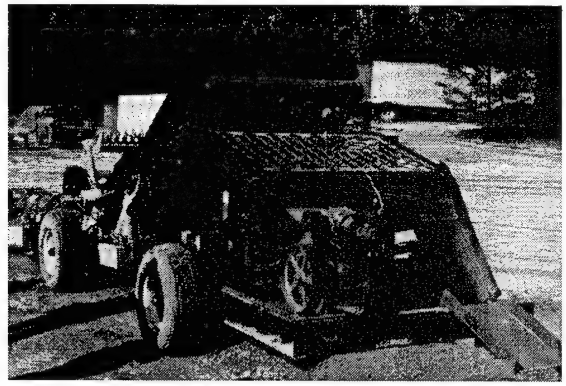
(1) The push handle is too low. Operators had to stoop uncomfortably when moving the cart.

(2) SOF testers stated a need for a larger selection of tools than those listed in the Test Plan. Suggested additional items include assorted wire cutters, digging tools, shaped charge devices, chemical neutralization devices, a mine detector and manuals. SOF representatives also expressed a need for compartments to better organize the various items in the cart. Tailoring of the load for a given work effort or an additional cart would avoid aggravating the weight problem.

f. What is the overall suitability of the demining kit in the humanitarian demining environment? SOF testers reported that the demining kit is highly suitable for humanitarian demining.

Berm Processing Assembly





1. The Berm Processing Assembly removes mines from berms created by mine clearing blades and plows. Refer to paragraph (D)(9) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test plan in Appendix D, Section IV, paragraph J.

2. Performance Evaluation:

a. Can the berm processing assembly remove 100% of all mines, using multiple passes, from an earthen berm cluttered with grass, brush, rocks and other ground debris created by mine breaching rakes, plows and blades? The Berm Processor Assembly (BPA) successfully demonstrated the concept of removing AP and AT mines from berms created by mine clearing blades. The BPA was evaluated against small berms (3 feet wide X 2 feet high) littered with an array of 12 AT and 8 AP mines. The BPA successfully demonstrated the ability to separate the mines, regardless of size or shape, from the earthen berm. The BPA separated 100% of all AT mines and 95% of all AP mines from the berm. The mines used were wooden surrogates that simulate the exact size and weight of real mines.

b. At what speed does the BPA clear? The BPA performed best when pulled at 2 MPH or less. When pulled greater than 2 MPH it was possible to overwhelm and stall the BPA. It should be noted that the BPA used during the OCDT was a small concept demonstrator and that a full scale version could increase these speeds.

c. Are removed AT and AP mines visible and on top of ground after the BPA performs? All the mines for this test were buried in the berm prior to making a pass with the BPA. After each pass of the BPA all mines encountered were on top of the ground and visible to the testers.

d. Can the BPA be easily attached to any commercial horizontal construction equipment vehicle? The BPA can be towed behind all commercial construction equipment. There is no interface between the demonstrator tested other than the mechanical attachment to the host vehicle. The prototype has the control box mounted on the berm processor. The control box will be mounted in the cab of the host vehicle for any future evaluation. Testers feel that a hydrostatic drive host vehicle would provide variable control over forward movement of the vehicle which is critical to the performance of the BPA.

e. Is the BPA interoperable with front or side-attached mine clearing blades? The BPA did not receive a test with the mine clearing rake on the same machine because the blade was not available by the end of the OCDT.

f. When combined as a system on one platform, can the BPA process berms created by the clearing vehicle without slowing the progress of the clearing vehicle? This evaluation was not performed because the clearing vehicles were not available.

g. Can the BPA be attached and removed from the clearing vehicle without the need for special tools or lift equipment heavier than a commercial light recovery vehicle's boom and winch? The prototype BPA is a simple tow behind device and therefore there are no issues associated with installation or removal.

h. Is the BPA simple to operate and maintain by host nation deminers in a humanitarian demining environment? The berm processor was very easy to install and operate. There should be no problems with host nation deminers using this equipment.

i. Is the field reparability and RAM performance suitable for the humanitarian demining environment? The BPA will require the same level of maintenance and knowledge as would complex construction equipment.

j. Are there any safety concerns with the BPA? There are many moving parts associated with the BPA. Standard warnings and cautions associated with construction equipment apply.

k. Are there any human factors issues associated with the BPA? There are no significant human factors issues associated with the BPA or its usage.

l. Is the BPA suitable for use in the humanitarian demining environment? The existing unit is a technology demonstrator. The prototype is not ready for deployment because it is too small and underpowered.

Mine Clearing Blades

1. The mine clearing blade and bucket developed under this program are designed for attachment to commercial construction vehicles to accomplish large area clearance. Refer to paragraph (D)(10) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph K.

2. Performance Evaluation:

Mine Clearing Bucket:

a. Can the Mine Clearing Blades clear all AT mines, in various soil types, from the surface down to those buried at a depth of 8" using a single pass? The bucket rake current design will clear AT mines buried to a depth of 10 inches. Mine clearing effectiveness will be relative to the operators ability to control the bucket. This design incorporated a tactile automatic depth control system that would maintain a preset depth. The proficiency of the operator to manually control the bucket in a mine clearing environment would be dictated by experience and training.

b. Can the MCB be attached to commercial construction vehicle such as a bulldozer in lieu of or attached to the platform's earth moving blade? The bucket rake is designed to be incorporated in a crawler loader multi-purpose bucket. The concept, using an agricultural tine configuration, could be development on a multitude of construction equipment platforms.

c. Can the MCB be easily attached to the clearing vehicle without the use of special tools? The bucket rake was designed as a continuation of the crawler loader bucket weldment. All tines and support beams were welded to simplify and strengthen the assembly. This concept could be developed into a bolt on kit that would be installed without the use of special tools.

d. Can the MCBs clear without exceeding the allowable combined capability of the tractor's normal load and blade dead load? A class 200 crawler loader was used as

the platform for the demonstration. The loader is capable of plowing the mines to a depth of 10 inches without stalling or track slippage.

e. What effect does the MCB have on AP mines encountered in an area cleared of AT mines? The system at the time of the demonstration was not mature enough to perform this portion of the evaluation.

f. Does the MCB create a berm in the demined area that would require subsequent berm demining? The soil is left in a cultivated state that would be suitable for farming.

g. Is the MCB capable of expanding the width of the initial cleared lane by means of consecutive passes? The Mine Clearing Bucket clears all AT mines in it's path and will clear all mines in each consecutive pass.

h. What is the effective rate (in acres per hour) that the MCB designs clear? This would be soil dependent. The Bucket Rake demonstrated an effective clearing rate of 1.2 - 2.4 acres per hour.

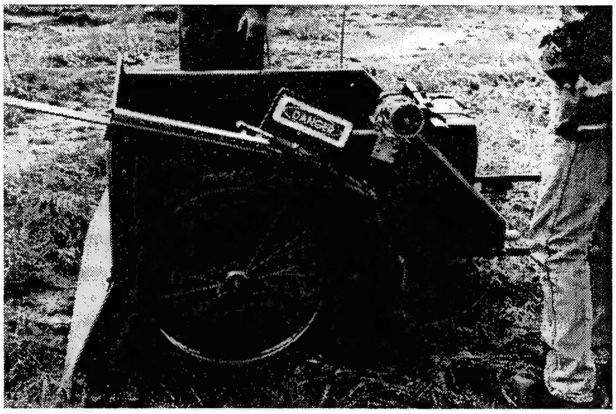
i. Can the MCB be easily repaired, within two hours, following damage from detonation of an AT mine of equivalent power to a TM-46 mine? This portion of the evaluation was not performed due to time constraints.

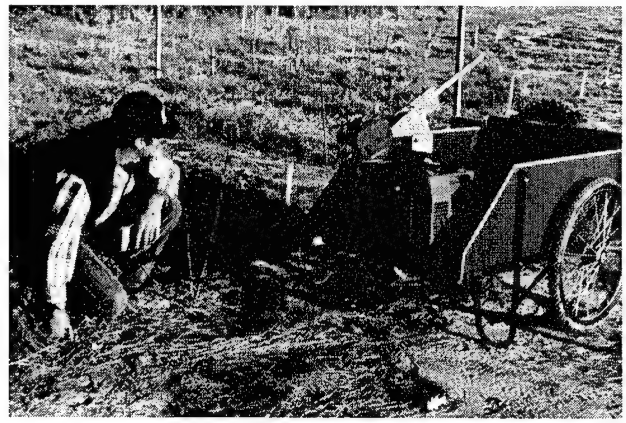
j. Are the MCB's RAM characteristics and modularity of design sufficient to support humanitarian demining needs? The Bucket Rake is a simple weldment and can be supported with "blacksmith technology".

k. Is the MCB inter-operable with the vehicle towed roller and the berm processing assembly? The MCB can be operated effectively with a towed roller and the berm processor.

<u>Mine Clearing Rake:</u> The rake version was not ready in time for the OCDT. The rake will be tested in FY96.

Grapnels





1. Grapnels are stand-off trip wire activation devices. Refer to paragraph (D)(11) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph L. The following evaluations are keyed to the measures of success for both grapnel systems.

2. Performance Evaluation:

Heavy Grapnel: The heavy grapnel test did not take place. In preliminary testing, the prototype system could not launch the grapnel for the 50 foot minimum distance considered necessary to be a practical demining tool. The Test Director decided not to test the prototype. However the concept of a grapnel with sufficient weight to clear tripwires in heavy vegetation is still viable. A redesigned heavy grapnel may be tested in the future.

Light Grapnel:

a. Can the light grapnel clear all the tripwires against which it is launched? There were five successful launches that covered a total of 30 tripwires. Of this total, the light grapnel tripped 23 wires for a raw score of 77%. There were three spots where testers placed 2 tripwires one above the other. In all three cases, the grapnel tripped the top wire and missed the lower one on the first cast. A second throw tripped the lower wires.

b. Can the distance to be thrown and clearance of overhead obstacles be adequately adjusted by the setting of the launcher angle? The throwing distance can be adjusted by setting the launcher angle. The average throw distance at the optimum angle was 57 feet. The light grapnel was originally expected to have a maximum throw distance of 150 feet. Given the throw distance performance of the prototype, adjusting to clear overhead obstacles would mean an unacceptable reduction range. Redesign to increase the maximum throw distance is needed to make the light grapnel more usable, and to make angle adjustment settings be of practical use.

c. Can the light grapnel launch direction be adequately set by pointing the demining cart (the launching unit will be attached to the demining cart)? The operator can accurately place the light grapnel by aiming the throwing arm.

d. Can the electric winch motor, which is powered by a battery/DC current from the generator, retrieve the grapnel through high grass/rocky terrain without stalling? The motor showed no indication of stalling, but it did not smoothly retrieve the grapnel. Testers suggested that a speed control be added to the winch. They also recommended a manual winch control in case a generator failure prevents the electric winch motor from operating.

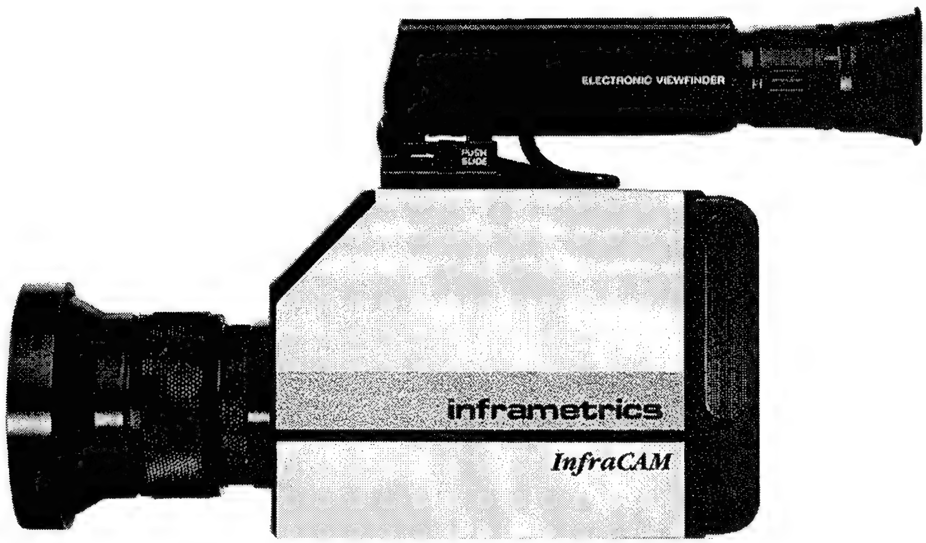
e. Does the grapnel hang up on limbs/debris during retrieval? The launcher propels the grapnel in a fairly high arc, which would cause it to easily become entangled in trees and tall vegetation. SOF testers suggested a delivery system with a flatter trajectory.

f. Can tripwires resting on the ground or just above the ground be snagged by the grapnel on the first pass? Seven of the ten wires that the grapnel missed were very low or laying in the ground. Future development with the light grapnel should improve its ability to clear low wires.

g. What other improvements are needed? The Kevlar line frayed quickly and broke. A longer lasting line is needed. There were also severe problems with line tangles which must be corrected.

h. Are there any safety concerns with the light grapnel? The grapnel throwing arm sweeps around in an approximately vertical plane from about fifteen (15) degrees below horizontal at the rear of the cart to about thirty (30) degrees below horizontal at the front of the cart. It moves with considerable force over much of the arc. **The operator <u>must</u> avoid the arm during the swing!** A "DANGER" sign on the thrower warns of this.

Handheld Trip Wire Detectors



1. The handheld tripwire detector uses a small IR camera to detect tripwires. Refer to paragraph (D)(12) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph M.

2. Performance Evaluation:

a. Can the handheld trip wire detector reveal the presence of any trip wire by manual positioning and by means of illumination?

(1) Operators could locate any taut tripwires in the open without outside (active) sources when they used the IR camera to carefully inspect tree trunks at likely attachment points. It was important for an operator to position himself so that a tripwire would be between his location with the sensor and a probable attachment point.

(2) Unless they were in direct sunlight, tripwires loosely placed on the ground proved extremely difficult to detect with passive IR sensors. The ground and foliage acted as heat sinks which quickly caused tripwires to assume the same temperature as the environment. While non-illuminated wires were very hard to find, the sensor picked up sun heated wires as a series of dots along the ground where they reflected heat directly back at the camera. These dots are distinct and readily identifiable.

b. Can the illumination component highlight a trip wire over a 5 foot horizontal distance in front of the operator, and from the ground to 6 feet high? Optimum detection occurred in the 5-7 foot range.

c. Can the UV/IR cameras and intensified light detect any (all) trip wires where they are attached to trees, loose wire in grass, etc.? Active heat sources made loose trip

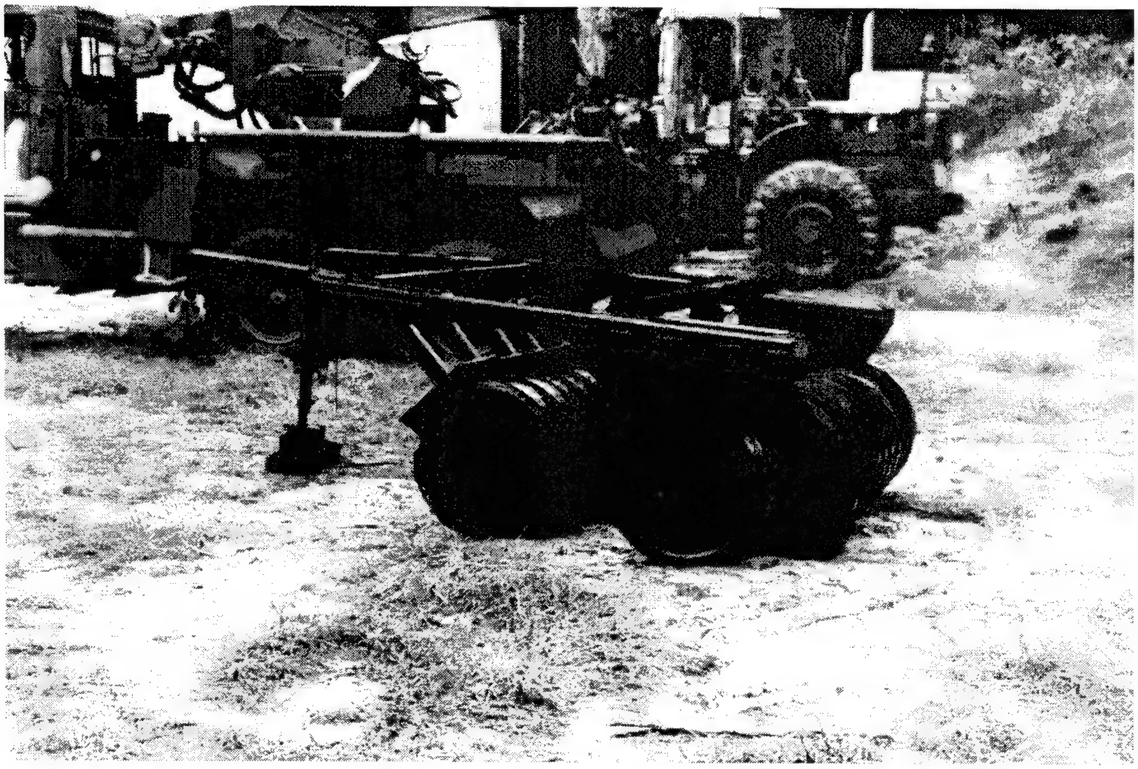
wires on the ground easy to detect when testers used a heat source of sufficient power to change the temperature of the target area. A 200 watt incandescent (visible light) source mounted in a reflecting hood provided sufficient energy to cause the wire to "shine" in the area being exposed to the light. Loose wire on the ground can be found when the light source is not more than 1.5 meters and the sensor is at two meters. A taut wire required no more than 5-10 seconds to heat sufficiently to be easily detected. A loose wire required approximately 10 seconds to heat sufficiently to create bright reflected dots. Shortly after the dots appeared an experienced operator could find and trace the wire to its tie-off points. Pronged fuzes such as those found on the M16 and the Valmara 69 would also stand out for detection when illuminated for 10-15 seconds.

d. Are there any safety concerns with the handheld trip wire detector? Given an operator who understands trip wire emplacement, the test did not identify any safety issues with the handheld trip wire detector.

e. Are there any human factors concerns with the handheld trip wire detector? The camera is very sophisticated. Although easy to use, the camera will not hold up well if handled roughly. It will be important to include proper care of this equipment in any training program for host nation deminers.

f. Is the handheld trip wire suitable for use in the humanitarian demining environment? The handheld trip wire detector is a viable humanitarian demining tool. This capability is very valuable in light of new technologies in tripwire fuzes. Some new designs do not require tension. They may be activated by touch.

Vehicle Towed Roller



1. Anti-personnel mine detonating rollers designed for commercial host vehicles. Refer to paragraph (D)(13) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph N.

2. Performance Evaluation:

a How many mines on three successive passes can the Vehicle Towed Roller (VTR) clear?

(1) The vehicle towed roller operated against four minefields as follows:

	Minefield 1 Flush buried	Minefield 2 Buried 2"	Minefield 3 Buried 4"	Minefield 4 Grassy field
Row 1	3 PMNs	3 PMNs	4 PMNs	4 PMNs buried 2"
Row 2	4 VS-Mk2s	3 VS-Mk2s	3 VS-Mk2s	3 PMNs flush buried
Row 3	4 M16s	3 M16s	3 M16s	4 VS-Mk2s buried 2"
Row 4	4 M14s	3 M14s	3 M14s	4 VS-Mk2s flush buried
Row 5				3 M16s buried 2"
Row 6				3 M16s buried 2"
Row 7				5 M14s buried 2"
Row 8				5 M14s flush buried
Totals	15	12	13	31

(2) The test plan called for the VTR to make 8 passes over minefields 1 through 3. These three minefields were in very hard ground. Testers decided to add the 4th minefield in the grassy field to see if the softer earth made any difference in performance. The same performance trend carried across all four minefields. The deeper the mines were buried, the lower the VTR's performance. A summary of results in each minefield follows.

(3) Minefield 1: Performance against flush buried mines was 100%. The VTR cleared all 15 mines by the end of the 4th pass. It took three passes to neutralize the PMNs, four passes to clear the VS-Mk2s, one pass for the M16s and four passes to clear all four M14s. The roller sheared all four M16s on the first pass, and repeated this performance on the second pass. Testers discontinued this portion of the test after two passes. The roller failed to clear any of the M14s on the first pass, but got all four on the second pass.

(4) Minefield 2: The roller performance against mines buried at 2" was 75%. It cleared all three PMNs by the third pass. Success against the VS-Mk2 was not good. The roller only cleared one of the three mines on the 6th pass. Performance against the M16 at this depth continued to be 100% on the first pass. The VTR did not clear any of the three M14s until the 7th pass. The roller took 7 passes to achieve its 75% rate against minefield 2.

(5) Minefield 3: The VTR neutralized 7 of the 13 mines buried at 4" for a 54% success rate. The roller cleared all four PMNs, but it took until the 7th pass to get the last one. The first three were cleared on the first pass. The roller cleared one of the 3 VS-Mk2s, taking until the 7th pass to do so. The roller cleared one of the M16s on the third pass. The VTR cleared one of the 3 M14s, taking until the 6th pass to do so.

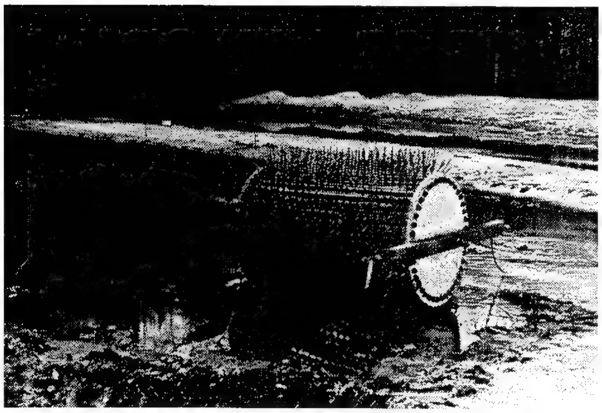
(6) Minefield 4: The roller made three passes against each row. It cleared all flush and 2" buried PMNs. The VTR cleared three of the four flush buried VS-Mk2 mines on the first pass. It cleared the fourth mine on the second pass. One of the four VS-Mk2s at 2" was neutralized. The roller got 5 out of the 6 M16s on the first pass. It did not clear the last M16 until the third pass. It cleared all 5 flush buried M14 mines on the first pass, and 1 of the 5 at 2" on the first pass. This was the only M14 at 2" that was cleared.

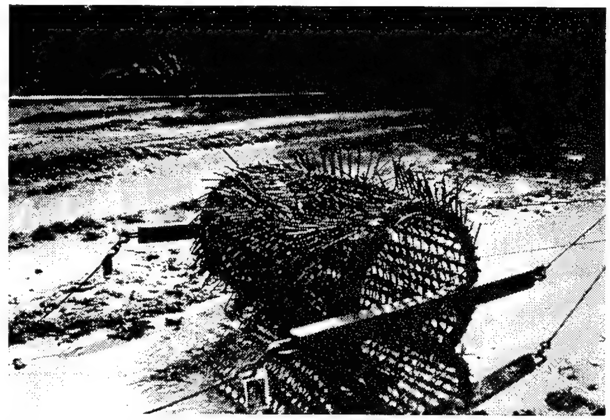
b How many PMN detonations can the VTR survive under the same interior roller without significant damage? Significant damage is defined as damage of a nature that prevents continuance of the mission. Blast testing was postponed due to neutralization testing requirements in conjunction with the mine clearing rake. All system testing should be completed during the second quarter of FY96.

c Can the VTR withstand bounding AP mine fragments without significant damage? Blast testing was postponed due to neutralization testing requirements in conjunction with the mine clearing rake. All system testing should be completed during the second quarter of FY96.

d Are the VTR installation and maintenance requirements suitable for an austere humanitarian demining environment? The prototype roller was easy to install to the host vehicle, requiring only two minutes. Maintenance requirements were suitable for an austere environment.

Towed Light Roller (Swamp Buggy)





1. An anti-personnel mine detonating roller designed to operate in watery areas such as rice paddies, and light enough to be towed by winch or by an animal. Refer to paragraph (D)(14) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph O.

2. Performance Evaluation:

a How many mines can the towed light roller clear on three successive passes over the same area?

(1) The following table shows the clearing performance of the towed light roller:

	Encounters	Cleared	Success Rate
All M14s	134	26	19%
M14s at 2"	113	24	21%
M14s at 4"	21	2	10%
PMNs	15	13	87%

(2) Design improvements to improve the performance of the swamp roller have been identified. The revised roller will be tested at a future date. SOF testers commented that the concept of using this roller with an animal in very austere nations should be tested. However it is unlikely that a draft animal will continue to pull a device that causes explosions.

b Can the towed light roller survive 10 each 1/2 lb TNT detonations without significant damage? Significant damage is defined as damage of a nature that prevents continuance of the mission. The Towed Light Roller withstood five M14 detonations. In each case, several tines and rods were bent, but the roller was easily repairable after each blast. However, after 5 1/2 lb TNT (used as PMN simulators) detonations, the roller was so heavily damaged that it could not have continued its mission. However, it was repaired and returned to service in three mandays.

c What is required in terms of time, tools and people to prepare the towed light roller for operation? It took 30 minutes using three people to emplace the anchor and roller

d What is required in terms of time, tools and people to repair/replace individual rollers following damage? After ten mine detonations, it took 3 mandays to return the device to a functional condition. Only basic tools (crescent wrench, sledge hammer etc.) were required.

e Are the earth anchors for pulley (block and tackle) components dislodged during use? The anchoring systems used were not dislodged during testing.

f Can pulley assemblies be moved to new anchor locations without any reconfiguration of roller hardware? Personnel were able to relocate the anchoring system without reconfiguring the roller.

g Does the roller "track" the path designated by the return tow lines? The tracking characteristics of the roller were satisfactory.

h Can the roller reverse direction without changing the configuration of the towing harness? The roller was able to reverse direction without adjustment to the towing harness.

i Are there any maintainability issues associated with the towed light roller? The roller proved to be easy to maintain.

j Are there any safety issues related to the towed light roller? Safe standoff from a mine blast must be considered when operating this device.

k Are there any human factors issues related to the towed light roller? SOF testers did not identify any human factors related issues.

l Is the towed light roller suitable for use in the humanitarian environment? The neutralization performance of the current towed light roller is inadequate for use as a stand-alone system.

Command Communications Video and Light System (CCVLS)

1. The heart of the CCVLS is a mini camera that mounts to a helmet or onto a pole. The camera is linked to a remote control station to include an audio link. A Refer to paragraph (D)(15) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph P.

2. Performance Evaluation:

a. Can the CCVLS light sources locate partially exposed landmines in holes, around or underneath obstacles, hard to reach areas or in bunkers using the variety of different mounting possibilities?

(1) The Command Control Video Light System cameras were effective at locating mines in various environments and conditions using the helmet mounted version and the telescopic pole

mounted version. Real-life demining scenarios were performed in the sand and unimproved road areas during the test.

(2) During the sand area test, a SOF operator wore the walk around unit and the helmet mounted camera to perform a demining operation approximately 75 to 100 feet from a safe perimeter zone where the perimeter link unit and down range unit were set up. The second camera on the tripod stood approximately 75 feet from the deminer which transmitted video back to the command post. The CCVLS equipment was then used with the Mini Mine Detector to locate and disarm an antitank mine. The command post was set up in a tent approximately 250 to 300 meters from the safe perimeter zone. The operator at the command post monitored all activities through the two cameras and communicated with the SOF operator via the two-way audio link. The audio signal transmitted by the SOF operator was clear and intelligible. The SOF deminer proceeded to locate, remove and defuze the mine while the CCVLS equipment recorded the entire procedure.

(3) During the unimproved road test, similar conditions existed as those during the sand area test. During this test the SOF operator used the CCVLS equipment, the Mini Mine Detector to locate the mines and a rigid foam for mine marking. The entire operation was also recorded on video and reviewed back at the command center. Again, the audio signal from the SOF operator was clear and intelligible.

(4) At various times throughout testing, the telescoping pole mounted camera was used to determine it's usefulness. The telescoping pole clearly demonstrated it is an effective demining tool as it could locate objects around corners and underneath vehicles.

(5) Possible areas of improvement would be to have removable rechargeable batteries with longer battery life and better range from the Walk Around Unit to the Perimeter Link Unit. Often, the test was cut short because the batteries were low or the distance between the operator and the down range unit was too great, thus cutting off communication. SOF personnel commented that the battery life should be at least six hours. At the OCDT, the batteries were sometimes drained after an hour of operation. The range between the WAU and the PLU should be at least 150 feet. In cold weather, this was as low as 50 feet. Test personnel also commented that the antennas and antennae mount must be more durable.

b. Is the two way radio communication system between the deminer and the operator at the command site an effective communications system? The audio signal from the SOF operator in the field and the operator at the command site was most often clear and intelligible. The only audio communication breakdowns occurred from low battery life.

c. How clear is the video quality at the command and control station that is transmitted from the perimeter link unit and the deminer's walk around unit? The CCVLS was used at ranges up to 300 meters between the field operator and the command post. The video images that were received at the command station were clear and of high quality. The video problems occurred when the command station was positioned behind a large bunker or when the SOF operator in the field would stray too far from the down range unit, thus breaking the signal. Line of sight is at times critical for the CCVLS system.

d. Does the CCVLS have any human factors problems associated with the equipment?

(1) No discomfort was reported by the operator when using the CCVLS equipment. The Walk Around Unit (WAU) simply fastens to the deminer's belt and is out the way of the deminer's arms and legs. The video cable simply runs up the back and connects to the camera which is mounted on the deminer's helmet. An audio cable also runs up the back to a headset that is

separate from the helmet. Therefore, the deminer is able to communicate back to the command post and have his hands free to perform any demining operations that are required.

(2) The equipment was quick and easy to set up, however, SOF test personnel had a number of suggested improvements. A PROTEC type helmet with camera mounted internal communications would make the system more comfortable and secure on the user's head. Test personnel also recommended removable, rechargeable batteries for the command station, perimeter link unit, down range unit and walk around unit. This would allow deminers to work without the interruption of charging low batteries.

e. Is the CCVLS safe to operate given the humanitarian demining environment? The CCVLS equipment was very safe and easy to operate.

Mobile Video and Light System (MVLS)

1. Helmet mounted mini-camera combined with a stand-off camera, both of which transmit to a remote location. Refer to paragraph (D)(16) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph Q.

2. Performance Evaluation:

a. Can the MVLS locate partially exposed landmines in holes, around or underneath obstacles, hard to reach areas, high grass, around corners, or in bunkers using the different mounting options? The MVLS cameras were useful in locating landmines in various environments and conditions using the helmet mounted version and the telescopic pole mounted cameras. The helmet mounted MVLS version allowed the deminer to transmit audio and video from the minefield back to the command post. The demining operations were recorded for reviewing and training purposes. The MVLS could be also be useful to complement the CCVLS when an additional camera is desired on a telescopic pole or on the helmet of another deminer.

b. Is the audio and video quality at the command station acceptable and clear?

(1) The MVLS was used at ranges up to 150 meters. The video images that were received at the command station were of high quality and no communications breakdowns took place at this distance. Because line of sight between the command station and the operator is sometimes critical, communications and video problems occurred when the command station was positioned behind a

large bunker. Additionally, extreme cold weather (approximately 20 degrees F) affects the audio and visual signals.

(2) Possible areas of improvement are battery life and the range from the Walk Around Unit (WAU) to the Perimeter Link Unit (PLU). At the OCDT, the batteries were drained after less than two hours of operation. The range between the Walk Around Unit and the Perimeter Link Unit should be at least 150 feet. In cold weather, this was as low as 40 to 50 feet. Testers also commented that the antennae assembly must be more durable.

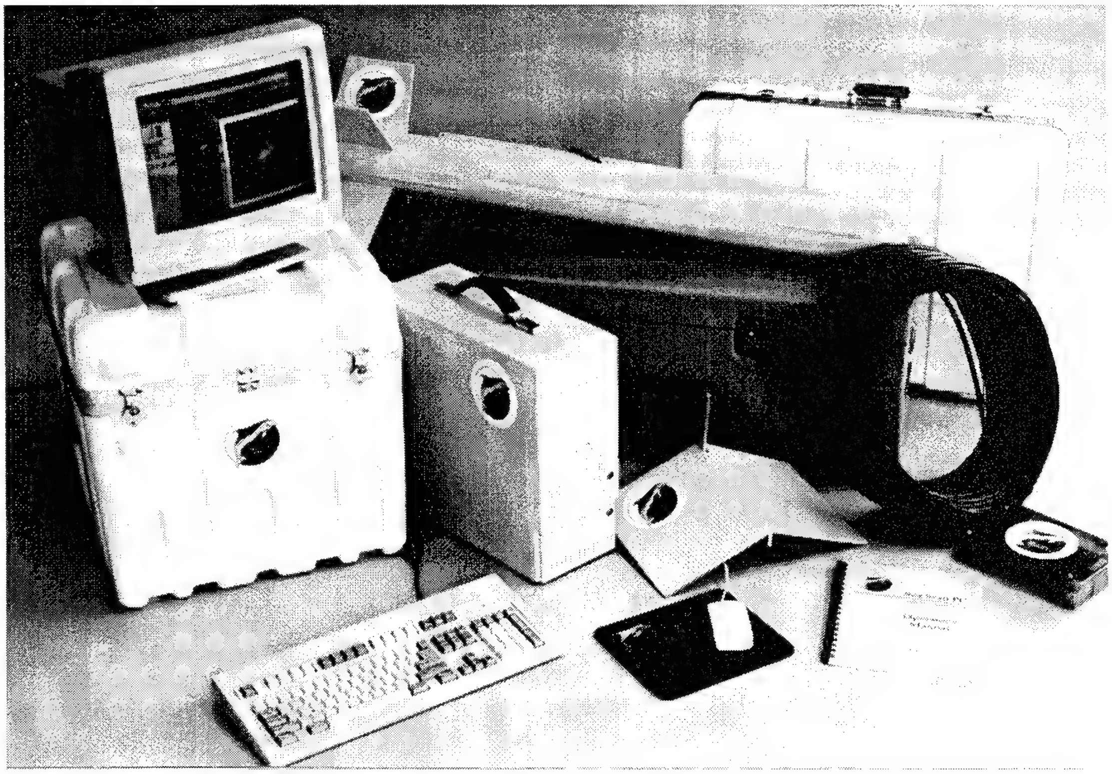
c. Are there any human factors issues associated with the MVLS?

(1) No discomfort was reported by the test personnel when operating the MVLS equipment. The Walk Around Unit (WAU) simply fastens to the deminer's belt and is out the way of the deminer's arms and legs. The video cable simply runs up the back and connects to the camera which is mounted on the deminer's helmet. An audio cable also runs up the back to a headset that is separate from the helmet. Therefore, the deminer's hands are free to perform all demining operations that may be required.

(2) Although the equipment was comfortable and easy to set up, SOF test personnel had a number of suggested improvements. A PROTEC type helmet with camera mounted internal communications would make the system more comfortable and more secure on the user's head. Test personnel also recommended removable, rechargeable batteries for the command station, perimeter link unit, and walk around unit. This would allow the operator to have more uninterrupted time with the MVLS system as batteries could be quickly switched when they reach low levels.

d. Is the MVLS equipment safe to operate given the humanitarian demining environment? The equipment was very safe and easy to operate.

Side Scan Sonar



1. A small sonar that transmits images to a computer. Refer to paragraph (D)(17) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraph R.

2. Performance Evaluation:

a. Can the side scan sonar identify manmade items/landmines in shallow water and if so, what are the diameters of the mines it can identify?

(1) Test personnel placed several different objects on the sides and at the bottom of the pond at the test site. The objects were a sledge hammer head, a spoked wheel, one half of a concrete block and an inert PMN mine. The sonar successfully outlined all four objects. These items ranged from 4 inches in diameter up to 3 feet in diameter. The sledge head was approximately 4 inches in diameter by 6 inches long.

(2) The first test run with the Side Scan Sonar was with no objects in the pond to provide a baseline of what was originally present in the pond. No objects were originally present and one side had a much greater slope of sand than the other. The first object placed into the pond was the cement block half. It showed up very well. The PMN inert mine was then put into the pond. It also showed up as a definite mine-like image and the rope that was tied to it could also be identified. The spoked wheel and the sledge head were put in last. The spoked wheel presented a very defined image as the individual spokes could be pointed out and identified. However, the sledge head seemed to be too heavy and sank into the sandy bottom. It could not be seen by the sonar imaging system. Finally, the test personnel pulled it out and set it carefully into the pond, not allowing its weight to bury itself into the sandy bottom. The image was then visible to the side scan sonar system. Although the imaging was best when the sonar's transducers emitted sound waves from both sides, this would not always be the case. If there was a smaller or even much larger pond, emitting sound waves from one side may be optimal.

b. Can the side scan sonar operate without interference when attached to a flotation device? There were no interference problems encountered when attached to the flotation assembly. Therefore, this particular flotation system was used throughout testing.

c. Can the side scan sonar towfish be maneuvered by an operator in a shallow water pond 15-30 feet in length? The towfish is easily maneuvered using a flotation assembly tied to a guiding cable. An umbilical cable ran from the personal computer to the 600kHz towfish. The towfish was attached to the flotation assembly and was manually guided using two test personnel. This procedure was easy to set up and the towfish was easy to maneuver. SOF testers recommended that a one man guidance system be developed using a flotation assembly that requires less manual pulling and dragging.

d. Are there any safety of use or human factors issues associated with the side scan sonar system? There are no safety or human factors issues that need to be addressed. It only requires one hour to train an individual how to operate the side scan sonar. This does not include the time to train target recognition. The sonar system is compact and can be easily set-up in approximately 10 minutes.

K9 Program

1. Mine detection using trained dogs. Refer to paragraph (D)(18) in the "Equipment to be Tested" Section of the Test Plan for a full description. The detailed test plan, including the measures of success for this system appears in the Test Plan in Appendix D, Section IV, paragraphs S and T.

2. Free Leash Performance Evaluation:

a. Can the dogs alert and sit within one meter of the mine? The dogs consistently alerted well within one meter of the actual mine location.

b. Can the dogs alert to buried and surface emplaced, metallic and non-metallic, on-road and off-route AP and AT mines 100% of the time? The dogs were tested against a total of 36 mines in four different test areas at Fort A. P. Hill. The dogs successfully detected 23 of the mines for a 64% success rate. The following are possible reasons for the lower than expected mine detection performance:

- The dogs may have been worked facing the wind. They should be worked with the wind. Wind direction data was not recorded so it is not known for certain if this was a factor.

- The strong scent of a tripwire masked a weaker mine scent in at least one of the 13 misses.

- Many of the mines were off of the cleared path making it difficult to locate them. However, the dogs located 100% of the trip wires in this environment.

- The data collector commented that handler training and familiarity with the animal is critical to success. SOF participants underwent a one-time training with assigned dogs, then went into test. It is possible that a longer association of handler and dog could have made a difference.

- The time during which a dog is effective is roughly two hours. It is possible that the dog "stopped working", but the handler did not notice it before the dog missed a mine.

- Mines under water were a problem for dogs to detect. They sensed that mines were present but were unable to pinpoint them.

c. Can the dogs locate tripwires without engaging them? The dogs alerted to every tripwire encountered, whether located on the ground, at ankle height or above head height. Tripwires may distract the animal from nearby buried mines, so once the wire is removed the area must be searched again.

d. Can the dogs effectively search for mines following an explosion? The dogs were able to find mines following a mine detonation in the same area.

e. Can the dogs effectively search for mines with scattered explosives in the area? Dogs were not able to find mines in an area where testers scattered pieces of TNT and C4.

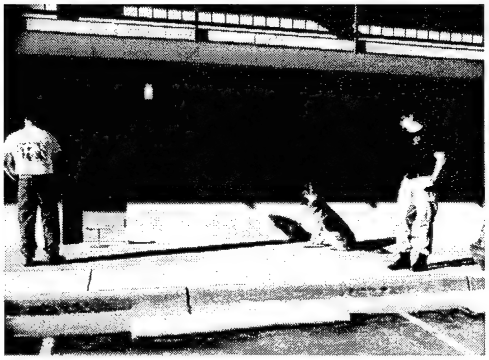
f. Can the dogs effectively search for mines in areas that have been exposed to fire? The dogs consistently alerted to mines in an area that had been burned.

g. Is the handler able to control the animal at a level sufficient to make the handler - leashed dog team an effective mine detection tool? In all cases, the dogs behaved as trained and always responded correctly to the handler.

h. For an area that is known to be clear, do any leashed dogs falsely alert to the presence of a mine? Dogs alerted to buried rotting wood several times. This is a result of their training to locate wood mines.

i. Are the use of dogs a viable technology in areas of the world where humanitarian demining takes place? A well-trained handler / animal team and a metal detector operator had a high detection success rate.

5. Checkmate System Performance Evaluation:



a. How well does the manpack and vehicle based sample collection system perform? The Checkmate system placed sensors near a total of 80 mines. 16 were vapor boxes, 33 were emplaced using the manportable backpack system and the remaining 31 with a vehicle. The dogs alerted to 6 of the remotely placed detectors (38%), 23 of the manportable backpack detectors (70%) and 18 of the vehicle detectors (58%).

b. Do the free running dogs reliably locate a mine in a suspected mined area as indicated by the confined dogs? The free running dogs performed poorly, locating only 3 of 36 mines. The Checkmate free-running dogs were not well controlled. The handler could give the dog a general direction of travel. The handler / dog team did not follow controlled patterns that would allow assurance of complete area coverage. Dogs were frequently playful and jumpy. They moved more than necessary in a minefield environment. The dogs did not always return directly to the handler upon the command to return. Training and dog/handler bonding require additional work.

c. Can two or more dogs consistently alert on a collection filter that had been placed near a known mine? Dogs were able to verify the alerts of other dogs.

d. For a suspected mine, can one dog alert to a sample using the "Checkmate" technique? The dogs exhibited the ability to verify the existence of a mine anytime the vapor collector obtained the scent.

e. For an area that is known to be clear, do any Checkmate dogs falsely alert to the presence of a mine? The free running dogs falsely alerted six times during the test. There were no instances where the confined dogs alerted to a sample that did not contain an explosive sample.

f. Are the use of dogs a viable technology in areas of the world where humanitarian demining takes place? Yes - this test and other ongoing operations around the world demonstrate that dogs are providing the best mine detection capability in the world.

Conclusions

On-Road / Off-Route Detection

1. Vehicle Mounted Detector: Vehicle Mounted Detection: The metal detector was able to find fragments of metal ranging from several kilograms to a gram. System operators were able to see all of the mines buried at normal operational depths with the metal detector. In field use, the Thermal Neutron Analyzer (TNA sensor) was able to determine if metallic targets were anti-tank mines or not, and can potentially determine if a target contains down to a half pound of explosive. The visual systems were not tested because of bad weather and no conclusions can be drawn.

2. Vehicle Mounted Mine Detector:

a. The VMMD system demonstrated the capability to detect anti-tank mines at various depths using the IR/UV stand-off sensors and ground penetrating radar close-in sensor. Antipersonnel mines were difficult to detect. The VMMD system had trouble detecting the VS-50/TS-50 series as well as the M14 antipersonnel blast mine. The VMMD system's overall mine detection rate for the off-road environment was 50%. However, the VMMD detected 92% of the antitank mines in the Sand, Patterned Field and Unimproved Road areas while detecting 33% of the antipersonnel mines.

b. The GIS display located on a personal computer at the control center is very easy to operate and accurately displays the vehicle path, vehicle coordinates, the IR and UV targets received from the target recognition software, and the GPR detections. Also, the image quality of the IR cameras was excellent considering that the ideal light and temperature conditions were nonexistent during testing.

c. The VMMD was difficult to set up and maintain as it was configured at the demonstration. System operation and system training for the current VMMD design was extremely difficult and time consuming, thus making it unsuitable for humanitarian demining.

3. Ground Based Quality Assurance: Although this system did not enter formal test, it did demonstrate the ability to capture images, allow an operator to manipulate them to identify mines and to identify mines automatically. The potential exists for a such a system to economically detect mines, and to confirm the removal of mines for quality assurance. Future development should include an improved mast

Mine Clearers

1. Tele-operated Ordnance Disposal System: The system operators of the TODS were effective at remotely excavating buried land mines and also at remotely clearing heavy vegetation so mine detection devices could search the area. The vegetation cutter and radio control subsystems are robust and effective. The digging arm concept is valid but a more reliable hydraulic arm is needed and the metal detector configuration needs improvement.

2. Improved Mini-flail: The improved mini-flail should be tested as soon as the prototypes are ready.

In-Situ Neutralization

1. Explosive Demining Device:

a. The EDD successfully neutralized all plastic, metal and wood AP and AT mines against which it was tested. It is easy to operate, safe and reliable. This system is a candidate for immediate use in demining operations. Modifications to enable the use of non-electric caps and / or detonation cord, to make the mount adjustable and to produce it in various sizes will increase effectiveness and safety of use should be considered if this system is procured.

2. LEXFOAM: The LEXFOAM system performed well and is a good humanitarian demining neutralization option. Planners need to consider the need for water, nitrogen and propane sources in the host nation, and that it will not detonate if exposed to heavy rain for approximately 10 minutes.

3. Chemical Neutralization:

a. The capsulated ethylenetriamine fired from Gun 1 successfully neutralized all AP and AT mine targets through burning.

b. The diethylzinc in cartridge form using Gun 2 neutralized three out of thirteen mines with autocatalytic decomposition.

c. The brominetriflouride failed to neutralize any of the six target mines. There are two possible reasons for the performance of this alternative, both of which can be solved with further development.

d. The use of chemicals to neutralize mines without detonation is viable. The benefit to a system that destroys mines without introducing additional fragments is a big plus.

4. Mine Marking and Neutralization: The foam was able to mark, neutralize, and aid in the removal and destruction of anti-personnel land mines. It functioned in cold and warm weather, as well as under wet and dry conditions. The foam neutralized both pressure fuzed and tripwire fuzed mines. It is highly suitable for humanitarian demining because of its simplicity and ease of use. This system is complete and an excellent candidate for immediate use in humanitarian demining.

5. Shaped Charges: With a better stand-off device, the commercial oil well shaped charges are a viable option for humanitarian demining.

Individual Components

1. Modular Vehicle Protection: Fragmentation from the M16 and the MON-50 anti-personnel mines penetrated the armor kit installation. The 1/2 lb. detonations did not damage the MVP. The design as tested is not suitable for operational use. However, this test demonstrated that the application of armor kits to civilian vehicles will provide deminers some protection from small anti-personnel mines.

2. Blast Protected Vehicle: Fragmentation from the M16 and the MON-50 anti-personnel mines penetrated the armor kit installation. The 1/2 lb. detonations did not damage the Blast Protected Vehicle. The design as tested is not suitable for operational use. However, this test demonstrated that the application of armor kits to civilian vehicles will provide deminers some protection from small anti-personnel mines.

3. Mine Awareness Trainer: This system is a viable candidate for demining operations.

4. Mini-mine Detector: The Mini Mine Detector performance was equivalent to the US Army standard AN-19 PSS-12 mine detector and in a much smaller and lighter package. The MMD functions for a minimum of 10 hours on 4 AA batteries. Prototype units detected mines in a variety of conditions including cold weather, warm weather, rain, dry soil and sand and wet soil and sand. Several human factors changes required to make the MMD ready for fielding should be addressed in the follow-on demining program.

5. Extended Length Probe: Operators were able to determine the difference between plastic, metal and wood cased mines. A more conclusive test needs to be conducted in the follow-on demining program.

6. Extended Length Weedeater:

a. The extended length hand held weedeater demonstrated its value as a versatile demining tool where vegetation impedes the performance of a clearing operation. The system was successful at clearing most types of ground cover regardless of height or size or without detonating pressure fuzed AP mines although it is necessary to have optional cutting heads for thick woodland vegetation. There are numerous precautions that must be understood with the use of this tool by host nation deminers.

b. The wheeled version of the extended length weedeater demonstrated its value as a demining tool in open fields with but only with medium height grass type vegetation. The wheels exert enough ground pressure to detonate pressure fuzed AP mines. It is not as versatile a tool as the hand held version.

7. PSS-12 Mine Location Marker: The Marking System being attached to the Detector is a valuable improvement to the job of locating and marking landmines. This system saves time, improves efficiency, consolidates tasks and is safer for host nation deminers. The delivery system and marking products require some simple refinements. However, this system could be provided to host nation deminers for immediate use.

8. Blast and Fragment Container: The blast and fragment containers require no assembly and are constructed of single length S2 glass dry rolled into 1 inch thickness weighing approximately 85 pounds. The blast and fragment containers can withstand a minimum of one and a maximum of three antipersonnel mine detonations depending on the type of antipersonnel mines and the EOD method that is used. The 27" diameter blast and fragmentation container proved that it could contain the fragments from an antipersonnel fragmentation mine and protect a critical asset within three feet of the container.

9. Demining Kit: The kit will be a valuable aid for deminers. The prototype needs to be improved before it will be ready for the field. The hand cart was too small to hold all of the demining equipment that SOF testers would like to have. Further, the prototype was difficult to move by hand from the weight of the tools it now has. A second cart may be needed.

10. Berm Processing Assembly:

a. The BPA is viable and has the potential to be a valuable addition in demining operations where berm creating mine clearing rakes or plows can be used.

b. When feasible, the compatibility test with a mine clearing blade on the same host vehicle should be performed and the results distributed in a follow-on report.

c. The potential for this device justifies its further development into a model that is capable of being demonstrated in an actual demining operation. A larger, more powerful and robust unit will be needed for real world demining operations.

11. Mine Clearing Blades: An easy to fabricate and effective aid for demining operations in large open areas such as fields and urban areas.

12. Grapnels: The light grapnel performed well except for low loose ground wires. Areas for improvement are to increase its range, increase its ability to trip low wires, improve line control, make the winch performance smoother and provide a launcher with a flatter trajectory.

13. Handheld Tripwire Detector:

a. Infrared sensors enhanced by high wattage light sources allow above ground tripwires and command detonation wires to be quickly located at stand-off distances out to six meters.

b. Loose wire on the ground can be found when illuminated by a light source.

c. This capability is very valuable in light of new technology touch activated tripwire fuzes.

14. Vehicle Towed Roller:

a. The Vehicle Towed Roller demonstrated a high clearance rate against flush buried mines. Performance dropped off as the depth increased.

b. The vehicle towed roller is easy to install and use.

15. Towed Light Roller:

a. The towed light roller cleared 87% of the PMNs encountered and 19% of the M14s encountered.

b. The towed light roller is easy to install and use.

16. Command Communications Video and Light System:

a. The Command Communications Video Light System cameras were effective at locating mines in various environments and conditions using the helmet mounted version and the telescopic pole mounted version. The audio signals from the SOF operator in the field and the operator at the command site were most often clear and intelligible. The video images that were received at the command station were clear and of high quality.

b. The CCVLS equipment was very safe and easy to operate, and from a human factors standpoint, the equipment was quick and easy to set up and did not cause discomfort to the operator. Test personnel considered the CCVLS to be very well suited for humanitarian demining, primarily to monitor and record demining operations. SOF personnel commented that the CCVLS would be an excellent tool for a SOF team involved in training host nation personnel. The telescopic pole mounted version with the umbilical cable is effective when searching for mines and booby traps in hard to reach places.

17. Mobile Video and Light System:

a. The MVLS cameras were useful in locating landmines in various environments and conditions using the helmet mounted version and the telescopic pole mounted cameras. The system

has value because it allows SOF personnel to evaluate demining operations in live minefields that they themselves are not allowed to enter. This system can also be used to assist in training and in conducting after action reviews.

b. The video images that were received from the MVLS camera at the command station were of high quality and no communications breakdowns took place at distances up to 150 meters. The MVLS equipment is safe and easy to operate and does not cause discomfort to the operators. However, a PROTEC type helmet with a mounted camera and internal communications would make the system more comfortable and more secure on the user's head. Test personnel also recommended removable, rechargeable batteries for the command station, perimeter link unit, and walk around unit.

18. Side Scan Sonar:

a. The Side Scan Sonar confirmed that a sonar-based system can reliably reveal mines that are exposed on the bottom of shallow water areas. The sonar successfully outlined all four objects that were placed into the man-made pond. These items ranged from 4 inches in diameter up to 3 feet in diameter. The resolution could be even better by using a 1.2MHz towfish instead of the 600kHz model used at the OCDT. Training in target recognition will be easier, as will the accuracy at identifying targets.

b. The towfish is extremely easy to maneuver using a flotation assembly tied to a guiding cable. However, SOF test personnel recommended that a one man guidance system be developed using a better flotation assembly. There are no safety or human factors issues that affect that the side scan sonar system and only one hour is required to train an individual on the operation of the side scan sonar.

19. K9 Program:

a. Free Leash:

(1) The use of dogs to detect mines is a valuable demining technique. The raw performance score at this test makes it appear that the leashed / free-roaming dog program is not as effective as had been expected. However there are a great number of variables involved with using dogs for detection. Performance may have been better if there had been more acclimation time, or if trip wires had not been used, or if the handlers and the animals had more experience.

(2) For this OCDT, the dogs performed better than either of the sophisticated sensor systems.

(3) This demonstration confirmed that there is potential for the use of dogs to detect mines.

b. Checkmate System Conclusion(s):

(1) It is critical that dogs be trained with an emphasis on behavior in minefields. The Checkmate dogs behaved as if in a traditional explosive or drug search role.

(2) The Checkmate dogs were not sufficiently trained to evaluate system effectiveness. The leashed dogs performed twice as well as the Checkmate dogs in the same minefields. Differences in training between the two systems should be examined to identify the elements leading to successful mine detection.

Recommendations

On-Road / Off-Route Detection

1. Vehicle Mounted Detection: Make the metal detector subsystem available for demining. Complete testing of the infra-red, ultraviolet and visual camera systems.

2. Vehicle Mounted Mine Detector: Continued development of a GPR based VMMD should be included in funding plans beyond FY95.

3. Ground Based Quality Assurance: That development of the Ground Based QA System continue and undergo test in accordance with the published test plan.

Mine Clearers

1. Tele-operated Ordnance Disposal System: The concept is valid and the following changes should be made and tested: Fix the GPS systems. Redesign the metal detector system or leave off entirely. Replace the manipulator arm with a standard Bobcat back hoe modified with cameras and air knife. A gripper is not necessary. Re configure the drive system. Add bushhog wheels for cutter to keep at fixed distance above the ground.

2. Improved Mini-flail: That the improved mini-flail be tested when the prototypes are complete.

In-Situ Neutralization

1. LEXFOAM: That the system be made available for demining, and that it be upgraded to incorporate the improvements as recommended by SOF test participants.

2. Chemical Neutralization: That a follow-on effort take place to develop a more effective system and to make this approach simple for host nation deminers to understand and use. The follow-on effort should emphasize the following areas:

a. Quantification of the reaction between the chemicals and the binder material in the explosive.

b. Improve the delivery system to make it simpler and safer, taking into account the human factors issues discussed in the performance evaluation.

3. Shaped Charges: That an improved stand-off device be developed prior to making the system available for demining.

Individual Components

1. Mobile Mine Awareness Trainer: That the suitcase version be reported as now ready to support demining operations and that the vehicle mounted version be evaluated as soon as possible.

2. Mini-mine Detector: The suggested improvements in the test results report should be made to the Mini Mine Detector in the follow-on demining program.

3. Extended Length Probe: The development of this system be continued, which would include hardware/software development to allow the automatic target recognition system to function in the follow-on demining program.

4. Extended Length Weedeater:

   a. Make the system longer.

   b. Add the suggested improvements to the prototypes and re-test.

   c. Add a counter-weight on the back end to make the unit easier to balance.

   d. Adjust the cutting head so that it is parallel to the ground.

   e. Include the extended length weedeater in the deminers kit, and include its proper use in the training program for indigenous deminers.

5. PSS-12 Mine Location Marker: More research for smaller, compact delivery system evaluate better marking substances.

6. Demining Kit: Continue development efforts to increase mobility and capability.

7. Berm Processing Assembly: That FY96 funds be used to continue development of this system.

8. Grapnels:

   a. That light grapnel development continue to improve its ability against low loose wires, to increase maximum throwing distance, to reduce the launch arc, to reduce line tangling and to increase winch performance.

   b. That the heavy grapnel be redesigned to improve its throw distance and tested in accordance with the test plan.

9. Handheld Tripwire Detector:

   a. Continue testing with new versions of trip wires as they are obtained.

   b. Look for other heat sources which can be combined with blowers to rapidly see the "moving" wire.

   c. Combine the sensors and light sources into a small complete package.

10. Vehicle Towed Roller: That the vehicle towed roller be redesigned to increase its performance against deeply buried mines.

11. Towed Light Roller: That the Towed Light Roller be re-designed to improve its performance against small AP mines such as the M14.

12. Command Communications Video and Light System:

a. This system should be favorably considered for additional funding to add the recommended improvements, and for making it available to the demining community.

b. That FY96 funds be used to upgrade the CCVLS for longer battery life, better range between the walk around unit and perimeter link unit, a more durable antennae and a better helmet mounted visual and communications module. This should be accomplished without increasing the system size and weight.

13. Side Scan Sonar: That a follow on program using an upgraded sonar be investigated. It would be a low dollar effort and should be funded sometime in the not to distant future, maybe FY96 or FY97. The improved sonar should be developed, tested and made available for humanitarian demining.